Compressed Air Magazine

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How Large Mill Saved $125,000.

Blaw-Knox Skill and Accuracy in Shop Pre-fabrication Made it Possible for Field Crew to Cut 6 Hours From Shut-Down Time.

This job was made for a pressure of 850 lbs. per square inch and temperature of 850° F. Valves are Carbon-Molybdenum Steel. Pipe is Carbon Steel.

Here is exemplified the money-saving, time-saving values of care and skill in designing and pre-fabricating, of experience and speed in field work.

Installation of this 9-ton assembly required the complete shut-down of the mill over July 4th. Total time allowed Blaw-Knox Power Piping Division for cutting out existing header and cutting in new header was 36 hours. The job was finished in 30 hours and the mill went back into operation one full shift ahead of time.

High-temperature, high-pressure piping calls for extreme accuracy in pre-fabrication and a sound engineering and metallurgical background.. Blaw-Knox—with its specialized skill, its unequalled facilities and resources, its highly developed procedures can save you time and money whatever the scope and nature of your piping job.

SCIENTIFIC CONTROL IN ALL PHASES OF PIPING PRE-FABRICATION

Blaw-Knox Power Piping Division has ample man-power and equipment to handle all elements entering into the design and fabrication of high pressure—high temperature piping. Where specified, control for the work includes:

Control in Bending
Control of Grain Size
Control of Stress-Relieving
X-Ray Inspection of Welds
Control of Heat Maintenance During Welding

BLAW-KNOX COMPANY

1525 Pennsylvania Ave., • Pittsburgh, Pa

CHRISTMAS SEALS

Help to Protect Your Home from Tuberculosis

ON THE COVER

OUR cover picture does not require a caption, so it bears none. The scene, reminding of the approaching Christmas season, is near Sainte Adele, Province of Quebec, Canada. The photograph is reproduced through the courtesy of the Canadian Pacific Railway.

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IN THIS ISSUE

FINDING the proverbial needle in a haystack should be easy compared with uncovering gold in the average placer deposit. Gravel running 50 cents in gold to the cubic yard is considered rich, yet it represents only one part by weight in more than 2,000,000 parts of sand and gravel. Nevertheless, modern dredges recover most of it. Profits are obtained by handling thousands of cubic yards of gravel daily. Our leading article tells about these huge floating plants.

●

EACH winter, some 200,000 persons go to the Laurentian Mountains, north of Montreal, Canada, for skiing and for other winter sports. Increasing numbers of them are from the United States, and word comes from across the border that the latchstring is still out. Despite reports to the contrary, we are informed that traveling in Canada is no more difficult for Americans now than it was before the war broke out. Moreover, American dollars buy more in Canada than they do at home. For more information on the appeal of the Laurentians in winter, read *A Canadian Switzerland*.

●

OCCUPANTS of the various offices and laboratories in the National Aluminate Company's building in Chicago, Ill., may choose a temperature to their liking merely by setting a thermostat. Details of this interesting structure are described in our third article.

●

IN EVERY industry inanimate watchdogs stand silent guard over process operations, correcting those that tend to go wrong and compiling a record of all that happens. These are the modern control and recording instruments; and like as not they are of the pneumatic type. The fundamentals of their operation are discussed by J. B. McMahon of The Foxboro Company.

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EDITORIAL CONTENTS

Gold-Digging Giants—*O.A. Fitzgerald*....6296
A Canadian Switzerland—*E.L. Chicanot*....6302
Comfort for White-Collar Workers—*Allen S. Park*....6307
Pneumatic Instruments for Automatic Control—*J.B. McMahon*....6311
Washing Gravel with Air....6317
One Point of Control....6317
No Slowing Down Traffic for Trucks....6317
Editorials—New Turbine Material—For Safer Driving....6318
Air Motor Drives Pump in an Emergency....6319
Flexible Core Wall for Dam in Earthquake Zone....6319
Industrial Notes....6320

ADVERTISING INDEX

American Air Filter Co., Inc....15
American Brass Company, The....23
American Steel and Wire Co....19
Bethlehem Steel Company....25
Bucyrus-Erie Company....21
Blaw-Knox Company....2d Cover
Combustion Engineering Co., Inc. 16
Conrader Co., R....24
Cook Mfg. Co., C. Lee....20
Crane Packing Company....8
Dayton Rubber Mfg. Co., The....32
Eimco Corporation, The....9
Garlock Packing Co., The....30
General Electric....12-13
Hercules Powder Co., Inc....10
Ingersoll-Rand Co....4, 11, 17, 22
Jarecki Manufacturing Co....30
Maxim Silencer Co., The....24
National Forge & Ordnance Co....24
New Jersey Meter Company....28
Norton Company....14
Rotor Tool Company....29
SKF Industries, Inc....27
Socony-Vacuum Oil Co., Inc....6-7
Square D Company....28
Staynew Filter Corporation....3
Texas Company, The....5
Toledo Pipe Threading Mach. Co., 28
Timken Roller Bearing Co., The 4th Cover
United States Steel....19
Vogt Machine Co., Inc., Henry....31
Waukesha Motor Company....26
Westinghouse Elec. & Mfg. Co....18
Willson Products, Inc....30

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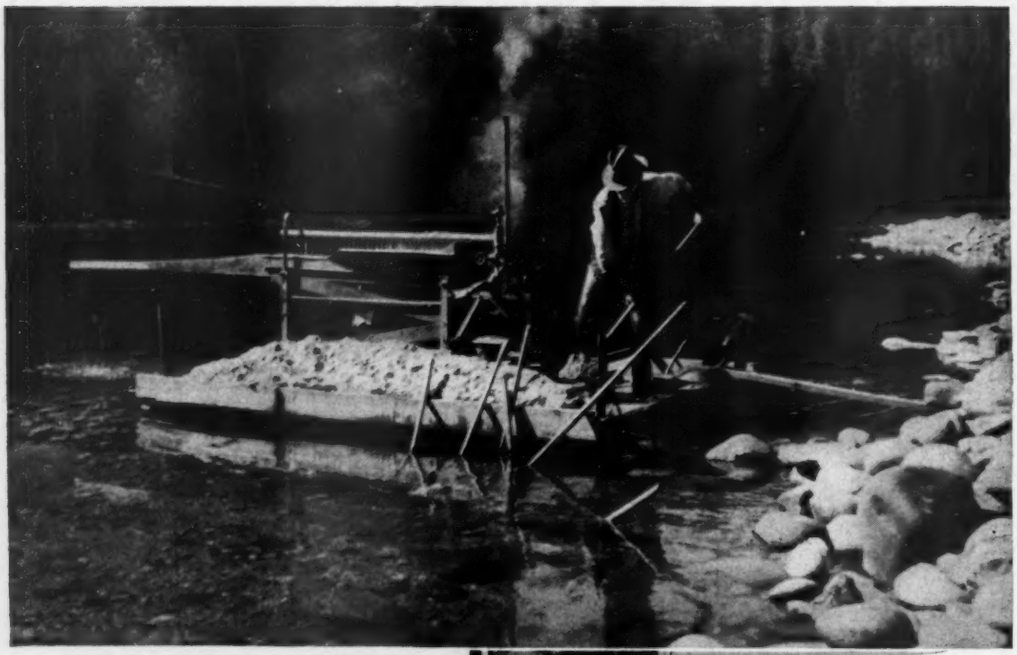


ONE-MAN WASHING PLANT

This homemade gold boat is operating on the Clearwater River in Idaho. It would take the man a lifetime to handle as much gravel as a big dredge digs up in a few days.

Gold-Digging Giants

O. A. Fitzgerald

THERE is something ironical in the fact that gold washing, which is commonly called the poor man's form of mining, has grown into a business that requires large capital. Through the use of massive machines, weighing up to 3,750 tons, millions of dollars of profit are being derived from gravels so lean that they would yield the hand panner no more than ten or twenty cents for a day's hard work. In California, dredges are doing well on gravel that runs eleven cents to the cubic yard. Fifty-cent gravel is a bonanza for dredgemen. The storied sourdough of yesterday's placer fields would very likely stand goggle-eyed if he could see today's mechanical gold-digging monsters take up in one bite more pay dirt that he could wash in a day, more in a day or two than he could handle in a lifetime. His bewilderment would be akin to that of the typical tourist as he gazes across the breath-taking vastness of man's most monumental engineering creation, the Grand Coulee Dam on the Columbia River in Washington.

One statistical tidbit from Grand Coulee is that 20,000,000 cubic yards of dirt and gravel—equivalent to a pile an acre in area at the base and nearly 2 miles high—had to be moved before any dam building could be done. Stupendous to be sure; but in Alaska, men and their enormous earth-moving creations are in the midst of a job three times as big. They aren't clearing the way for the foundation of a dam large enough to cast a shadow upon a 30-story building: they're after gold, the lure of which has impelled human beings to desperate deeds and heroic undertakings throughout the ages. Near Fairbanks, the United States Smelting, Refining & Mining Company has 16,000,000 cubic yards of gold-bearing gravel lying in a 60-foot blanket-like layer from 1,200 to 1,600 feet wide. The project stands out even in an age of super-engineering feats because about 60,000,000 cubic yards of worthless dirt and gravel must be moved away ahead of the dredge. The gravel blanket containing the gold lies 200 feet below the surface! First comes 125 to 150 feet of silt, then 60 feet of gravel that is too lean to be worth putting through a dredge.

Stripping away the 200-foot mantle is a 6-year job. It involves transporting a mass of material equal to twenty Boulder Dams a distance of 5,000 to 8,000 feet and elevating it an average of 148 feet. The transfer has been going on at the rate of 8,000 cubic yards daily for several years. In excess of 25,000,000 cubic yards, or more than the Grand Coulee builders handled, has been pushed aside, and still the job isn't half completed. Fortunately, it isn't necessary to wait six years to start obtaining returns. Sufficient waste already has been cleared away from one end of the gravel bed to permit a dredge to go to work. It will be ca-

MODERN DREDGE AT WORK

The bucket line, its lower end submerged, is visible at the right. At the left, or stern of the boat, the stacker is discharging tailings. The sloping flumes on the near side of the hull are discharges from the recovery room through which all the fine material passes. This dredge, which weighs 2,600 tons, is working in California. The picture on the opposite page shows the lower end of the digging ladder of a large dredge. The complete ladder weighs 900 tons.

pable of digging 60 feet below the new surface created by stripping. Each of its 70 buckets, connected in an endless chain, will bring up 10 feet of gravel with each bite, and 24 of them will dump their contents in the recovery room every minute. After the gold has been extracted, the stacker belt will pile the waste tailings in miniature mountain ridges behind the dredge. This will go on day and night for years until the slow-moving giant has eaten its way through the gravel.

Wonders of modern placer mining are these massive dredges, each of which weighs thousands of tons, costs from a few hundred thousand to a million dollars, and will handle from 2,000 to 12,000 cubic yards daily. Guided by a highly developed mining science, they are producing placer gold, tin, and platinum at the fastest rate the world has ever known. But for them, many millions of cubic yards of gravel from which mineral wealth has been removed would still be lying untouched, as they did during the early gold rushes when only small, manually operated equipment was available. Besides adding to the store of valuable metals, these dredges give employment both in the field and in the factories where they are made. It has been estimated that this kind of mining provides work for 50,000 men throughout the world.

In 1939 nearly 50 dredges materially helped California to maintain its position as our leading gold-producing state. Forty-six units were uprooting the deep gravels of Alaska, and they accounted for more than half of the territory's gold output. Nine were in use in Idaho last year; and lesser numbers in Montana, Oregon, and Colorado. The most extensive placer operations of all are in the Federated Malay States and neighboring parts of the Far East. Nearly 200 dredges are working there; but most of them are recovering tin, not gold. Platinum is also being produced in this manner in Alaska, Colombia, and in other areas.

Supplementing the bucket-line dredge are lesser mechanical plants. They represent a relatively new technique involving equipment that costs far less than a dredge and that can work in places where a dredge cannot. They are of various types and sizes. One class that is fairly numerous is a floating gold-washing plant similar to that on a gold dredge. However, it is without means for digging, and the gravel is fed to it by a separate excavating machine, usually a dragline, that travels on land. The washing plant is known in some placer districts as a "doodlebug." Such an outfit is used where sufficient capital for a dredge is not available, where the gravel deposit is too small to warrant purchasing one, or where the layer of gravel is so shallow that the pond would not be deep enough to float one.

There are also different kinds and arrangements of nonfloating washing plants. Many of them consist of sluice boxes to which gravel is supplied by trucks, carryalls, or bulldozers, the waste being removed by dragline or other suitable equipment. These outfits are really modifications of the hand-fed set-ups that were widely used by the pioneer placer miners; but they have been made more productive by introducing modern dirt-moving machinery. Their greatest disadvantage, as compared with floating washing plants, is that they cannot be readily moved along with the gravel-supplying apparatus. Consequently, the haul becomes increasingly longer until,

HYDRAULIC MINING

Monitors hurl powerful streams of water that wash the gravel and sand down into sluice boxes or other apparatus for recovering the gold. This type of placer mining flourished in the early days and is still of importance in some sections.

finally, the washer must be shifted to a more convenient location. Plants of this kind are necessarily employed for working bench deposits of gravel left above present watercourses by ancient streams. Such deposits are often buried and then opened up through drifts. The same method is frequently employed in mining frozen gravels in the Far North. Because it is not possible nor economically practicable in many instances to pump water to the gravel beds, the alternative course is to transport the gravel to water.

Then there are miscellaneous smaller plants ranging down to the one-man rocker, sluice, and panning outfits. In addition, there is hydraulic mining. If all these various placer operations are grouped, the total is imposing. There are more than 6,000 of them in the United States, including Alaska, and they are found in eighteen states. Their number is decreasing, however, the high point having been reached in 1932 when hundreds of persons, who had never seen a placer claim, sought to eke out a living by panning gold. Some of them succeeded, but the vast majority failed because few of the auriferous gravels remaining within reach of hand operations are rich enough to yield as much as a dollar for a day of hard work.

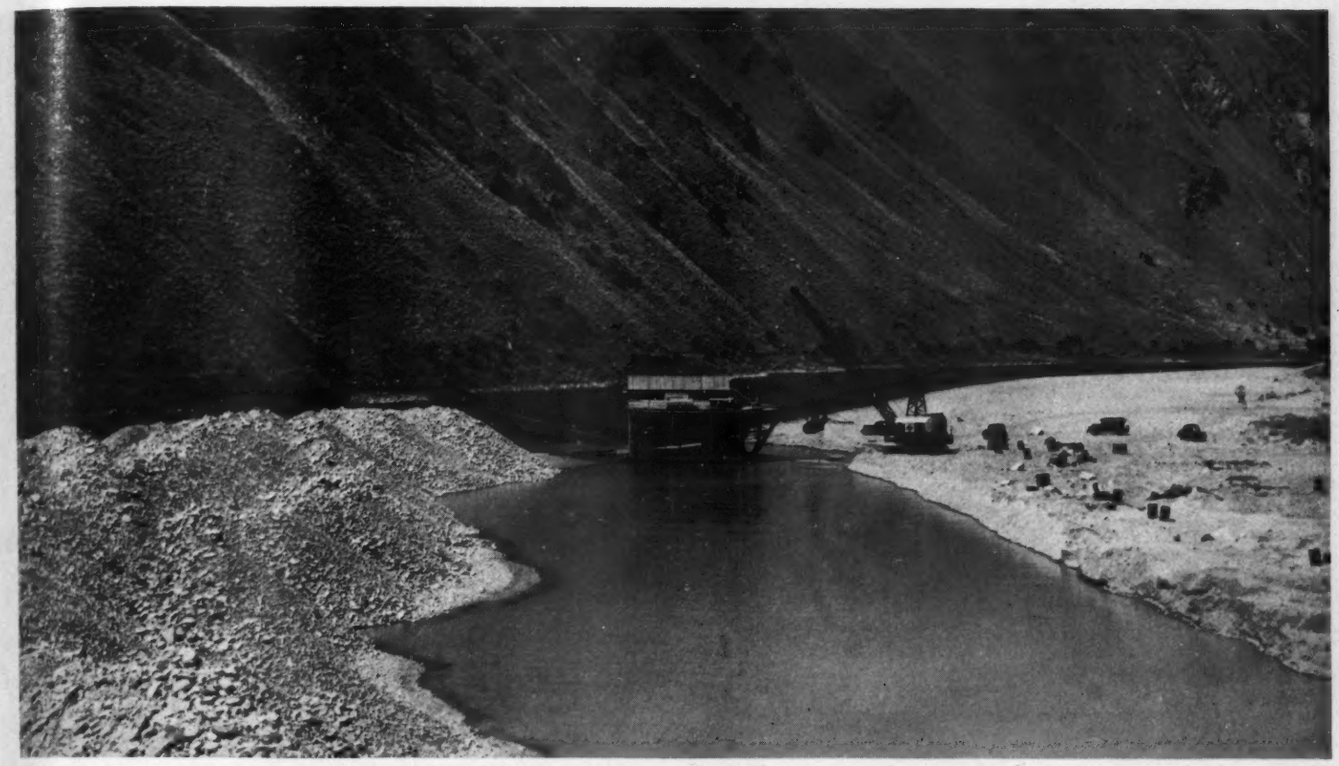
When gold rushes are mentioned, most persons think of California in 1849, of the Klondike in 1898, or of other familiar spurts when individual miners panned hundreds of dollars a day, when tent towns sprang up overnight, and when gold dust was the ruling medium of exchange. Around such scenes much of the history and romance of gold mining have been written, yet more of the precious mineral has been mined since 1900 than in all the years that went before. Sixty per cent of the world's gold has been produced since 1910; and during that period dredges have grown bigger and gone down deeper. Lode mines contribute the major part of the mineral, and as time goes on and more placer deposits are worked out the proportion will increase steadily. In the United States, where placer mining is a relatively greater factor than it is in most gold-producing countries, approximately one-fifth of the output is derived from gravels. The Homestake Mine in South Dakota is the nation's largest producer and bids fair to continue so. In second place is the Utah Copper Company, and its gold is a by-product of copper mining. Third on the list are the placer operations of the United States Smelting, Refining & Mining Company in Alaska. The next five places are held by lode mines; and in ninth position is Yuba Consolidated Gold Fields, a California dredging concern.

The first connected-bucket gold dredge started operations in 1895, near Bannack, Mont. Unknown to the miners farther west, a dredge built by the Bucyrus Company had been excavating on the Chicago Drainage Canal for several years before that time. A Montana mining man, Samuel S. Harper, saw it while on a visit to Chicago, and instantly recognized its possibilities in placer mining. Already there was need for such a machine, for the cream had been skimmed off the auriferous gravels around Bannack and at nearby Alder Gulch, which mining history generally regards as the richest placer bed the world has ever known. Harper ordered a dredge from the Bucyrus Company, and it went to work in September, 1895. It was capable of digging to a depth of 25 feet. Mechanical troubles developed, but Harper had seen enough to convince him that this type of equipment was what was needed, and he raised more money with which to have the dredge rebuilt by the Bucyrus Company.

The remodeled unit, its digging range increased to 35 feet, had a 75-foot ladder with a continuous chain of 5-cubic-foot buckets that moved at a speed of six to twelve buckets per minute. The gravel was treated in sluice boxes carried on a trailer scow, and the tailings were run over-

GETTING READY

Persevering small operators still cull considerable gold from the river beds. The picture shows a group setting up a washing plant on the Salmon River in Idaho.



A DECAPITATED DREDGE

This type of floating washing plant is known in some areas as a "doodlebug." It has a stacker for handling tailings, but no digging mechanism, the gravel being supplied to it by a crawler-mounted dragline that travels on land. Outfits of this kind cost far less than dredges and are suitable for working shallow gravel deposits.

board at the rear. The dredge was successful from the beginning of its service in 1896, and did much to revive the lagging interest in placer mining and launched an industry that grew rapidly. With few exceptions, the Bucyrus Company, now Bucyrus-Erie, built the first 100 dredges operated in the United States, and to date it has constructed approximately 225 such machines. As early as 1903 a dredge with 13-cubic-foot buckets was in use, and since then some with 18-cubic-foot buckets have appeared. Although the general trend has been towards larger units, it is the stated opinion of the Bucyrus-Erie Company that most placers that would seem to justify dredges of maximum size can be more profitably operated by a number of medium-sized machines.

The size of the dredge is largely controlled, of course, by the depth to which digging must be carried to reach the lower part of the gravel bed where most of the mineral is found. Early dredgemen thought 60 feet was the greatest depth attainable; but a machine that can go down 150 feet is reported to be under construction, and experts say a 200-foot digger is not impossible. Deep dredging involves complex problems. The gravel is often so firmly consolidated that it can be broken up only with difficulty; and the toughest steel obtainable is required for the buckets and other parts of the digging mechanism. In Alaska and Siberia one must cope with frozen ground. Thawing with steam was formerly resorted to; but it is said that cold water has lately been circulated for the purpose and been found satisfactory.

American manufacturers supply the world with most of its dredges. Transporting them to the remote areas in which operations are frequently conducted is a big job in itself. Several units in various stages of completion have been towed across the Gulf of Mexico to Colombia and on up its rivers to the placer fields. Yuba Consolidated Gold Fields is so large an operator in California that it builds its own dredges and also makes them for others. Its engineering division is the Yuba Dredge Manufacturing Company. Speaking of field problems, H. A. Swain, engineer of that concern, says: "To most people it might appear to be a hopeless situation to have 1,400 tons of miscellaneous machinery and structural steel dumped on a beach in Alaska early in September and be faced with the prospect of having to move it 20 miles for reassembly and having it operating by November 15. Yet this was done. Twelve miles of the haul was along the beach and eight miles along a river, using the streambed for a highway and at times moving through water two feet deep."

Eight dredges, dismantled so that no piece weighed more than 7,000 pounds, were flown into the heart of the New Guinea jungle. All the pieces were unloaded from boats on to the beach. Forty-five minutes after taking off, a plane deposited a load of parts at the gold field. Weeks would have been required to make the trip overland. Besides flying in the dredges, which totaled 18,000 tons in weight, planes have brought an additional 30,000 tons of supplies and equipment to the field.

The greatest problem facing the dredging industry in this country is to find deposits for future exploitation. However, the supply is ample for a few years to come. Dredgeable gravel in California is conservatively estimated at 2,000,000,000 cubic yards. One company has enough ground to keep it busy for twenty years. In some sections of the West, where virgin ground is scarce, dredges are working over piles of old tailings which still contain considerable gold that escaped the relatively inefficient washing plants of former years.

Illustrative of large-scale placer operations is a dredging project inaugurated last September near Sunbeam, Idaho, by the Snake River Mining Company. This concern is a subsidiary of Silas Mason Company, Inc., a well-known New York contracting firm. It may seem surprising at first that such an organization should embark upon a gold-mining venture; but, after all, dredging is primarily an excavating and dirt-moving job—work in which this company is thoroughly experienced. The dredge is operating in the valley of the Yankee Fork of the Salmon River at an elevation of about 6,200 feet. The Salmon River flows around three sides of an elevated igneous structure in central Idaho that geologists call "the great Idaho bath-

olith." The Yankee Fork comes down the southern slope of this lofty area and enters the main stream about 10 miles east of Stanley. It has a minimum flow in the dry season of 40 cubic feet per second. The dredge began working at a point about 3½ miles upstream from the confluence. The company has a strip of ground 7 miles long and averaging 800 feet in width. It contains about 15,000,000 cubic yards of dredgeable gravel. The unit will travel back and forth across the width of the strip, gradually making its way upstream. When it reaches the upper limit of the deposit it will be dismantled and hauled to some other place.

The valleys in this section of Idaho have been known to be gold-bearing for many years; but the remoteness of the area and the difficulties of working the ground nullified previous efforts to develop it. The material is not amenable to panning, hand-sluicing, or other small-scale placer methods because most of the gold lies at depths of from 10 to 16 feet. The gravel varies in thickness from 30 to 35 feet and contains numerous stones ranging in size from cobbles to large boulders. There is comparatively little pea gravel and sand, and the deposit is so well consolidated that it requires heavy machinery to dig it. The location is 85 miles from the nearest railroad, and the connecting road has many sharp turns and reaches an elevation of more than 8,700 feet, presenting obstacles to freighting in heavy equipment.

After testing the ground in 1939 by means of drill holes and excavated pits, the Snake River Mining Company placed an order with the Bucyrus-Erie Company for an 8-cubic-foot connected-bucket pontoon dredge. The manufacturer subcontracted the building of the pontoons and substructure to the Olson Manufacturing Company of Boise, Idaho. These portions of the boat, knocked down into sections small enough to handle, were trucked 260 miles to the dredging site. The largest single pieces were the pontoons, each of which measures 10x10x27 feet, and a special permit had to be obtained to move them over the highways. Everything else, including all the machinery, was shipped from eastern points by rail to Mackay and trucked the remaining 85 miles.

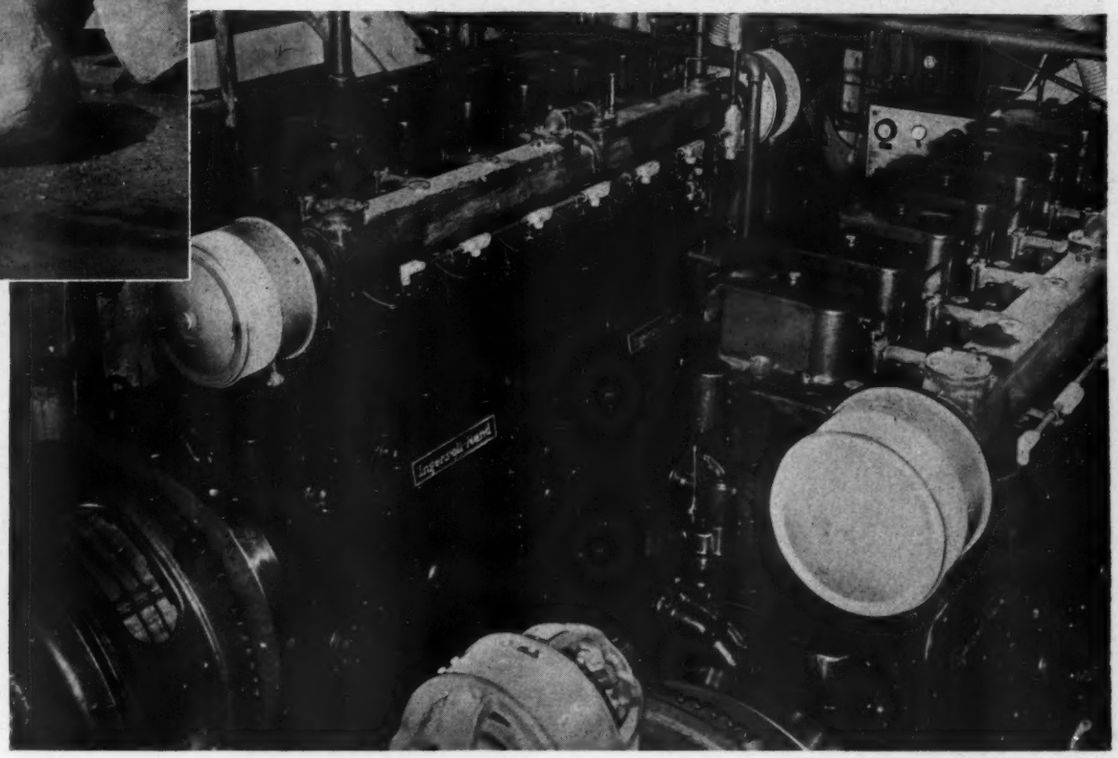
The dredge, which is of all-steel construction, except for the housing, weighs approximately 1,200 tons. The hull is 112½ feet long, 54 feet wide, and 10½ feet deep. The digging ladder is 85 feet long and on it are mounted 71 buckets, each weighing 2,700 pounds, that excavate and dump at the rate of 26 every minute. The maximum digging depth is 30 feet. The stacker ladder is 90 feet long and is equipped with a conveyor belt 42 inches wide. The normal rated capacity of the dredge is 195,000 cubic yards per month. This means that about 6½ years will be required for it to handle all the gravel in the deposit.

Although the dredge is rated at 8 cubic feet, its construction is of a much heavier order than that usually found in a machine of that capacity. For example, the pins that hold the buckets on the line are 5½ inches in diameter, or 20 per cent oversize. The upper tumbler shaft, through which the bucket line is driven, is 16 inches in diameter and is turned by a 200-hp. motor. Other parts that will be under great stress have been made exceptionally large and strong. All these precautionary measures have been taken to increase the effectiveness of the unit in the resistant ground and to guard against breakdowns in a region that is 200 miles from the nearest foundry or machine shop.

The gravel brought aboard the dredge passes through a revolving trommel screen driven by a 50-hp. motor. Powerful jets of water play upon the material to break up the gravel and to wash adhering fines off the larger stones. The smaller, gold-bearing

LATEST IDAHO DREDGE

The Snake River Mining Company placed in service last September at Sunbeam, Idaho, the 8-cubic-foot dredge pictured on the preceding page. It was built to extract the gold from 15,000,000 cubic yards of gravel lying in the valley of the Yankee Fork of the Salmon River. Because of the difficult working conditions it will encounter, the digging mechanism was made extra strong. The dredge is powered with electricity that is generated by two Ingersoll-Rand Type S 445-hp. diesel engines each driving a General-Electric 234-kw. generator. These units are seen below. The view at the left shows some of the boulders, weighing up to a ton or more each, that were brought aboard by the bucket line.



sand and gravel goes through holes in the screen, while the oversize is discharged through the end of the screen and on to the stacker conveyor belt that disposes of it astern. The trommel screen was originally perforated with ⅜-inch openings, but these have been slightly enlarged because the first few weeks of operations disclosed that some coarse gold-bearing material was not being saved. The fine material that passes through the screen is delivered by launders to sluices on each side of the dredge. There are sixteen double-decked sluices with 2,400 square feet of area containing riffles that catch the heavier gold and permit the lighter waste to move along. Following the sluices are two Pan American clean-up jigs in which the material is agitated by water, the gold settling by reason of its high specific gravity. Concentrates are amalgamated with mercury in a Denver Equipment Company amalgamation barrel, and the amalgam thus obtained is retorted in the company's headquarters on shore to extract the gold.

The preferred form of power for a dredge is electricity, and in an out-of-the-way location such as this one current must be generated aboard. It goes without saying that a reliable, low-operating-cost plant will increase profits both by effecting economies and by insuring against lost dredging time. Accordingly, careful thought was given to the selection of the equipment. Fuel transportation costs and other considerations favored diesel-engine-driven generators, and it then remained to choose the most suitable machines from the standpoint of dependability, compactness, and operating efficiency.

The two engines selected are Ingersoll-Rand Type S units such as have given successful service in diversified industries for a number of years. Each is a 7-cylinder model of 10½-inch bore and 12-inch stroke having an operating speed of 600 rpm. and a sea-level rating of 445 hp. Each is direct connected to a 234-kw. generator. The compactness of the engines is an especially desirable feature, as space on the dredge is limited. Each is 7 feet high, 3 feet 4 inches wide, and 18½ feet long overall, including the generator. The engines are equipped with Burgess air filters and intake silencers and Maxim exhaust silencers. Starting air is furnished by an Ingersoll-Rand Type 30 compressor driven by a Wisconsin gasoline engine. The generators and all motors are of General Electric manufacture.

The primary purpose of the pontoons, which are bolted together to form the hull, is to give the dredge buoyancy, but two of them are utilized as fuel-oil tanks. Each has a capacity of 15,000 gallons. This oil is pumped from the pontoons to a daily supply tank in the engine room by an Ingersoll-Rand Cam-Pump. Another Cam-Pump handles lubricating oil: it serves to remove spent oil from the crankcases by means of a flexible hose and also to deliver fresh oil into the crankcases.

The engine cooling water is circulated through closed systems, there being one for each unit. The water is pumped through the engine water jackets to an overhead surge tank, from which it flows by gravity through a heat exchanger and then back to the engine. The cooling medium used in the heat exchangers is water from the pond in which the dredge floats. These systems are serviced by four Ingersoll-Rand Motor-pumps, two for the engine water and two for the pond water.

About 30 men are employed on the dredge, which is operated on a 24-hour basis. H. L. Myer, vice-president of Silas Mason Company, Inc., is in general charge of the dredging activities and T. M. Patten is resident manager and dredge master. Living quarters, mess hall, and offices have been built about 2 miles upstream from the dredge.

SAINTE AGATHE IN WINTER GARB

A picturesque settlement north of Montreal whose favorable topography makes it a popular rendezvous for skiers. It is typical of many villages in the Laurentian Mountains that have been given a welcome economic lift through winter sports.

A Canadian Switzerland

E. L. Chicanot

THE Laurentian area, that vast rugged, wooded region of diminutive mountains and countless lakes that stretches northward from the backdoor of the City of Montreal, has long been regarded by Canadians and their American visitors as the superbest of natural playgrounds. Sportsmen hied with rod and creel to its lakes and streams in the spring for unsurpassed fishing. Hunters roamed its woods in the fall and took heavy toll of moose and deer. Inns and cottages came increasingly to dot the beauteous rolling expanse to accommodate the throngs that sought recreation on the shores of its waters in the summer months.

But with the advent of winter the Laurentians went into almost complete hibernation. The first snow fell upon hostelries and cottages deserted and boarded up against the coming of another spring. Lakes and rivers awaited in ice-bound silence the thaw that would bring back the angler. Roads were hidden under the heavy white mantle that covered the countryside, for no attempt was made to keep them open because it was purposeless The daily train, pushing up through the frost-decorated landscape, alone shattered the tingling stillness as it pulled up periodically at slumbering little French-Canadian villages that were indistinguishable one from another.

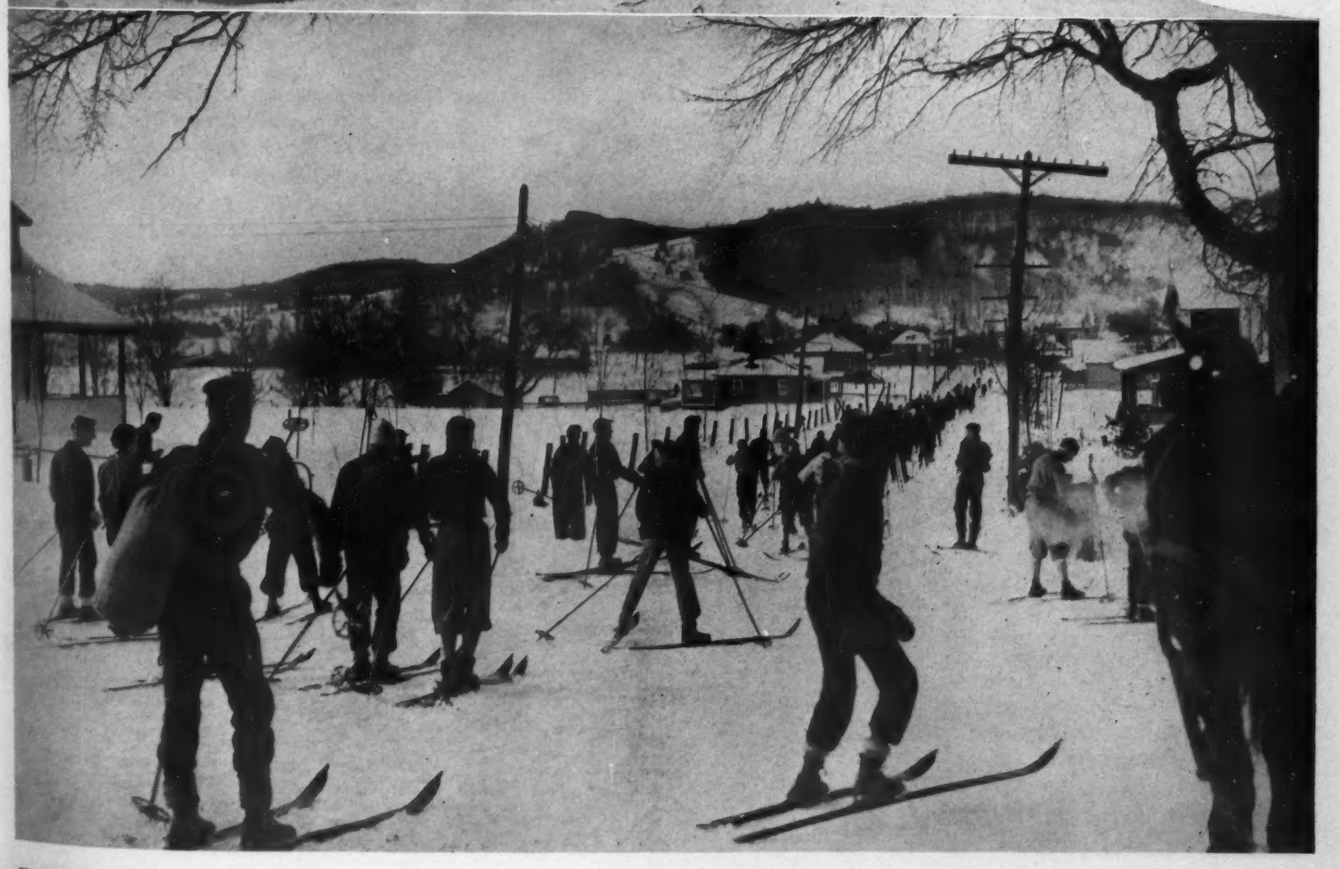
But all that has astoundingly changed. Today, the Laurentians are an all-year-round playground, furnishing sport and recreation to native and visitor without interruption. And what is more, the region is more popular, attracts greater numbers from a wider area, is more vivid and colorful, and pulsates with more activity in the winter than in other seasons. A Canadian Switzerland has developed, where thousands of Canadian devotees of winter sports and a swelling army of their friends from across the line are finding the acme of seasonal pleasure and which is proving increasingly profitable to the growing number of individuals that cater to their wants and needs.

The explanation lies in the manner in which skiing has gripped the people of the continent, and in the convenience, climatic dependability, and unparalleled facilities of the Laurentians for its indulgence. Formerly, winter sports in Montreal were largely confined to one's environs—skating or curling on a neighboring rink, snowshoeing or tobogganning on Mount Royal. But since skiing has become so popular, Canada apparently being infected in the first place by the United States, the metropolis has been emptying itself to an increasing extent into the mountainous playground to the north. And as word spread abroad of the splendid sport Montrealers were enjoying there, they were joined by visitors from an ever-widening region. As a consequence, something unique in winter-sports

FREE FOR THE WEEK END

Between December and the middle of April, twenty or more special trains for skiers are run out of Montreal every week end bound for the Laurentian highlands. Aboard them, amid a forest of skis, prevails an atmosphere of informality. The first passengers get off 30 miles out: some go as far as 90 miles. Sleighs or tractor trains are on hand at the stations to transport to the hillsides those who wish to ride. Many patronize them; but the majority prefer to use their own powers of locomotion. Quickly adjusting their skis, they set out along trails even before the train has pulled out.

All photographs furnished by Canadian National Railways and Canadian Pacific Railway



places and atmospheres has come into being.

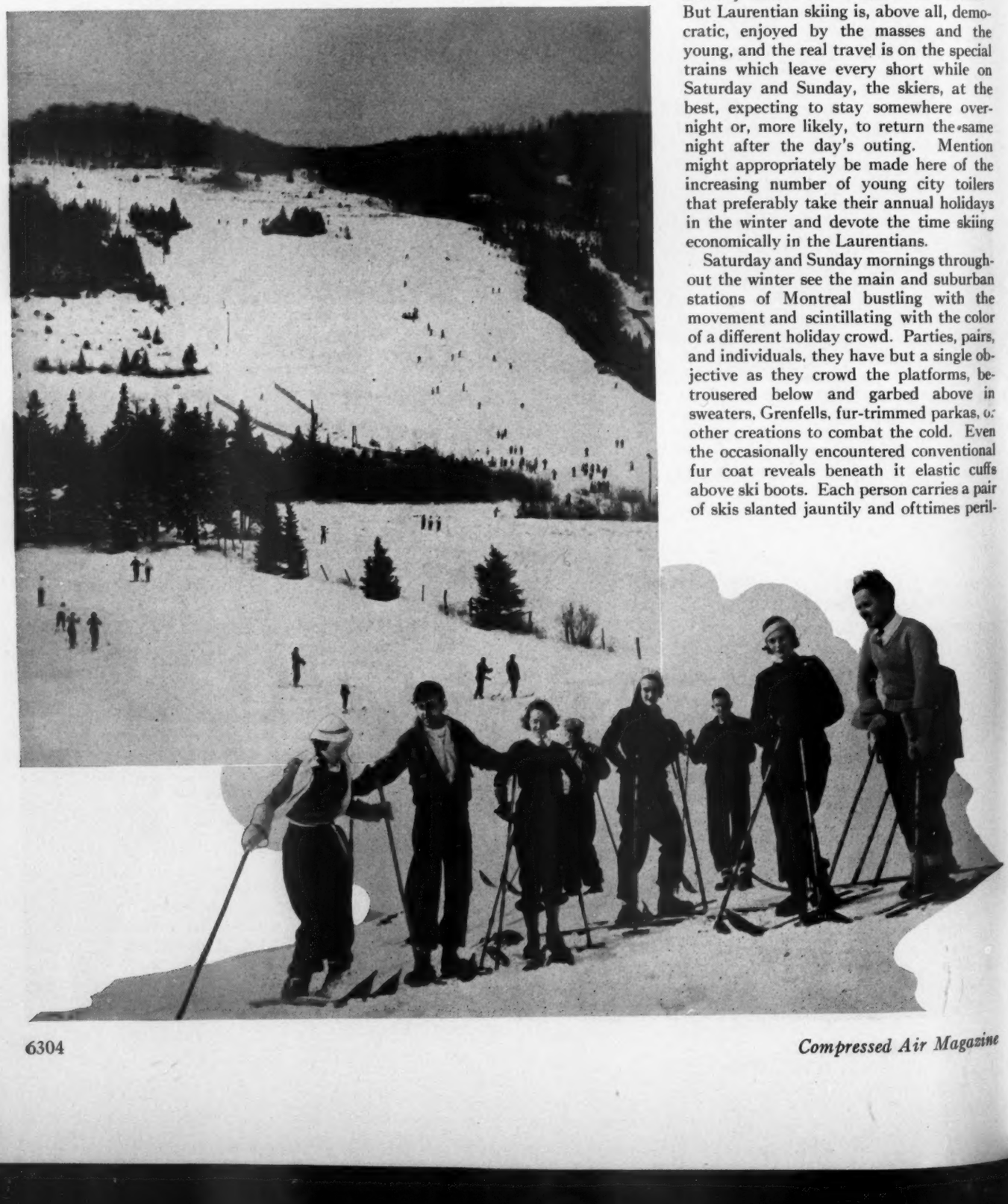
A few figures are impressive. The skiing season in the Laurentians commences with definiteness around Christmas and lasts until about April 15. In that period the railways transport some 200,000 persons into the area between Shawbridge, which is 30 miles from Montreal, and Mont Tremblant, which is 90 miles distant. From 30 to 40 trains make the trip weekly, and of these more than twenty are week-end runs during which 10,000 to 12,000 individuals are carried to and fro between Friday and Sunday night. They are from every walk of life, with a common love of ski trails and slopes; and though the majority must perforce make the excursion at a minimum of expense, many have to be fed and accommodated—another aspect of the economic side of the picture. Perhaps the imagination can paint something of the scene of bustle, color, and gaiety attending such an exodus. Certainly to have traveled on a ski train and spent a week end in the winter-clad Laurentians is an experience out of the ordinary.

There are, of course, those with more money and time who are able to take their winter diversions in larger doses and remain for protracted periods at the few luxurious resorts that have long flourished in the territory. The comparatively few Montrealers that fall in this class are considerably swelled by visitors from Ontario and across the border, the latter being seen almost any morning in the course of the season at a suburb of the metropolis transferring from the regular New York train to one running up to the mountains. Then there is that in-between group that can let it be known it does not work on Saturday mornings and that escapes on Friday evening. They journey for the long week end, spent at inns or cottages, on what is superciliously called the "Mink Coat Train." But Laurentian skiing is, above all, democratic, enjoyed by the masses and the young, and the real travel is on the special trains which leave every short while on Saturday and Sunday, the skiers, at the best, expecting to stay somewhere overnight or, more likely, to return the same night after the day's outing. Mention might appropriately be made here of the increasing number of young city toilers that preferably take their annual holidays in the winter and devote the time skiing economically in the Laurentians.

Saturday and Sunday mornings throughout the winter see the main and suburban stations of Montreal bustling with the movement and scintillating with the color of a different holiday crowd. Parties, pairs, and individuals, they have but a single objective as they crowd the platforms, betrousered below and garbed above in sweaters, Grenfells, fur-trimmed parkas, or other creations to combat the cold. Even the occasionally encountered conventional fur coat reveals beneath it elastic cuffs above ski boots. Each person carries a pair of skis slanted jauntily and ofttimes peril-

OVER HILL AND DALE

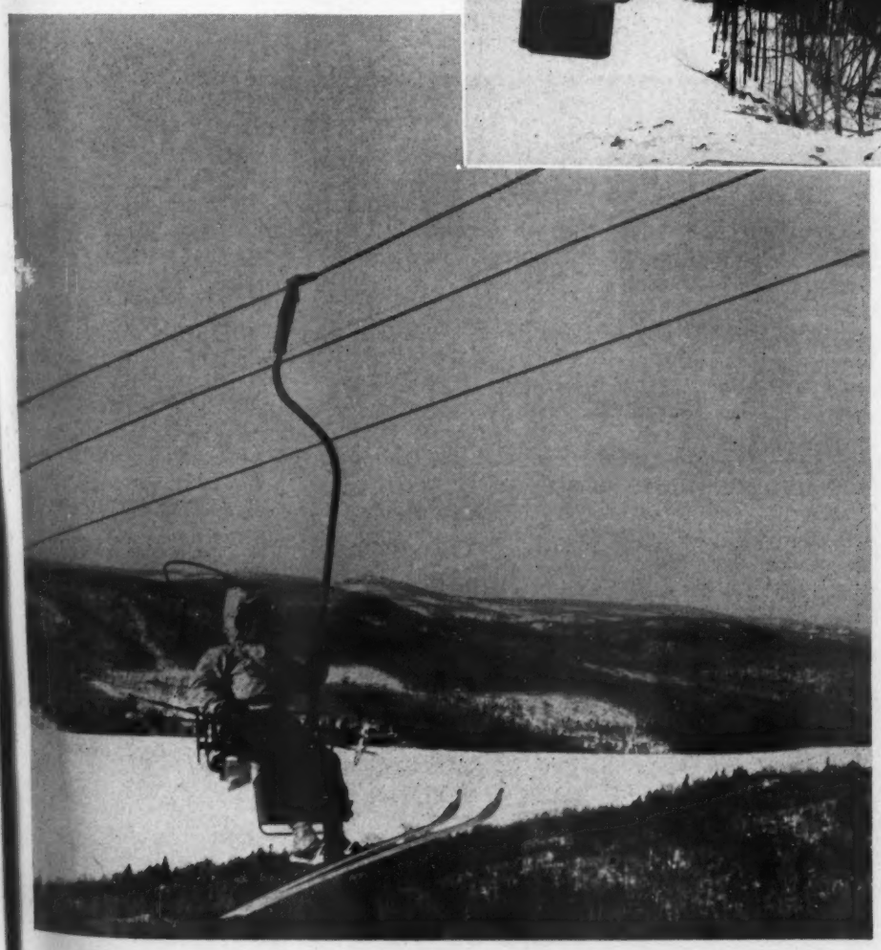
From morning until night, skiers of both sexes, most of them youthful, indulge themselves in the sport, the scope and tempo of their activities depending upon individual proficiency and inclination.



ously across the shoulders, and nearly all have packs of varying sizes on their backs. They are the young men and women, the students and workers of the metropolis, and their friends from elsewhere, free for the week end.

The trains they board are of extraordinary length—longer, much longer than any others pulling out of Montreal. Getting on a car at a suburban point one is struck at once by the novelty of the atmosphere. The seats are arranged back to back to accommodate four passengers, and the several inches of space between them is strapped off in five sections for the carriage of the skis. As one glances down the length of the coaches, prospect is of one vast crop of skis pointing heavenward, out of everybody's way and perfectly harmless. Between these hickory rows the skiers lounge informally. There is a great deal of laughter and chatter; but for the main part the excursionists are conserving their energy, looking ahead eagerly to skiing off to some favorite slope upon their arrival.

Within two hours, from Shawbridge on, the travelers begin to drop off. The train pulls in at some drab-painted little station, and the young people, bubbling over with animal spirits, sort out their skis and step off on to the snow-covered platform. Waiting there are sleighs big and small, their owners hoping for clients. Some arrivals throw in their skis and, bundled up in fur rugs, glide off to cottages or inns. But the majority adjust them to their feet and, hoisting packs higher on their backs, set off along trails in the direction of distant hills. So it goes for the next two hours as the train climbs its tortuous way through Piedmont, Mont Rolland, Ste. Marguerite, Val Morin, and Val David, to the height of land at Ste. Agathe, continuing thence through St. Faustin and St. Jovite to Mont Tremblant.



AERIAL CHAIR LIFT

Tows of various sorts are utilized to conserve energy in regaining hilltops. Most luxurious of these are the aerial tramways, only three of which exist in North America. The one pictured here is at Mont Tremblant, where a wealthy Philadelphia winter-sports enthusiast has spent $1,000,000 developing a complete ski village.

The greater number of the young men and women gliding blithely away from the stations are out just for the day—all they can spare from their normal routine. They are making for some popular hill—69, 70, or 71—to spend hours there skiing, according to various degrees of proficiency, and climbing again through their own efforts or with the aid of mechanical tows, which have been markedly improved upon every year. Wearying limbs or gathering shadows betoken the closing of the day. One railway, penetrating a less frequented section of the Laurentians, sidetracks its trains at suitable points, and skiers make their excursions from them, returning for rest or for meals provided cheaply in the restaurant car. For others, home-prepared lunches

will probably come from their packs and will be eaten perhaps at a brush fire built in some sheltered spot. Or they may repair to a nearby house or restaurant engaged in that increasingly profitable business of catering to the week-end skiers.

Those that wish to stay overnight or the entire week end can do so comfortably but inexpensively. The inns which dot the region and formerly served only summer vacationists are now open all winter, and their number has multiplied. They are unpretentious places, but suitable for the purpose, having large open fireplaces and being decorated with French-Canadian hooked rugs and handloomed striped carpeting. Then, too, well-nigh all the natives welcome the opportunity of making a few dollars from this providential winter traffic, and nearly every cottage becomes a *pension* as the family surrenders its quarters to the skiers and retires to the back rooms. Simple but wholesome fare is provided, and the accommodations are adequate, all being in keeping with the informality of the outing. Life-long memories are stored up in the winter evenings about the blazing fires, the skis and ski poles furnishing the decorative motif of the rooms.

Then there are the few pretentious hostelries, to which reference has already been made, which have long been favorite summering places and centers for hunting expeditions but which now thrive because of the larger winter guest lists. There one skis under the most luxurious conditions. Sleighs transport clients, buried deep in furs, from the stations and, if desired, over the country trails to favorite hills. Ski instructors are available for initiating beginners or for improving the technique of those with experience. At least one resort has a famous team of Siberian husky dogs behind which the visitor can travel at a price; and at the same hotel, which has its own plane service, a regular stream of visitors from Canadian points as well as from the United States arrives by air.

Capital is being attracted to the region solely because of the future envisioned as a result of this swelling invasion of skiers. American money and enterprise have built half a dozen modern and efficient ski tows, the tickets sold to patrons being interchangeable. At Mont Tremblant, highest peak in the Laurentians, a complete ski village has taken shape at a cost of nearly $1,000,000 provided by a Philadelphia sportsman and financier. This microcosm contains shops, cottages, a school, an inn capable of putting up 300 guests, with loge and café. It features an aerial chair lift, of which there are only two more on the continent, and an endless chain of chairs which carries skiers up slopes to a comfortable chalet 1,300 feet above the village. It is at Mont Tremblant that the many ski competitions take place, bringing together the finest of international exponents of the art and providing thrilling spectacles for visitors.

But not at such places does one get an understanding of Laurentian skiing—an appreciation of the real position it occupies in the recreational life of a people. For that one goes to the hundreds of little groups dotting the long, white slopes in every part of the region, to the boys and girls who must squeeze their outings into a short time and take them economically, and who, within a few hours, actually gain the infinite in sport satisfaction at little expense. For skiing in the Laurentians is, as we have already said, the essence of democracy, an inherent love of sport and of the unspoiled outdoors.

This is patently exhibited as one journeys back from Mont Tremblant on a special ski train on Sunday night. To serve intermediate points, trains are "spotted" at the different popular centers, but many skiers wait for the last possible chance to get home, and groups are to be found waiting at a score of places. Indeed, as a train pulls in at a little station, misty in the gloom, some enthusiasts, who have torn themselves away from their sport with reluctance, will be seen spurting desperately toward the coaches, hurling themselves frantically up steps dragging skis and packs. Inside they stretch out in comfortable relaxation and add their quota to the bedlam of talk and laughter as stock is taken of the experiences of the day. At one end of the car a sing-song is in progress to the accompaniment of an accordion: as it pauses, a group at the other end breaks into French-Canadian folk songs. So it goes, as the train, with its freight of happy, healthy youth, journeys through the once silent and deserted Laurentians to Montreal where the travelers spill out upon the platforms and, with skis slung across shoulders, make their ways to numberless homes, ready for another week's work.

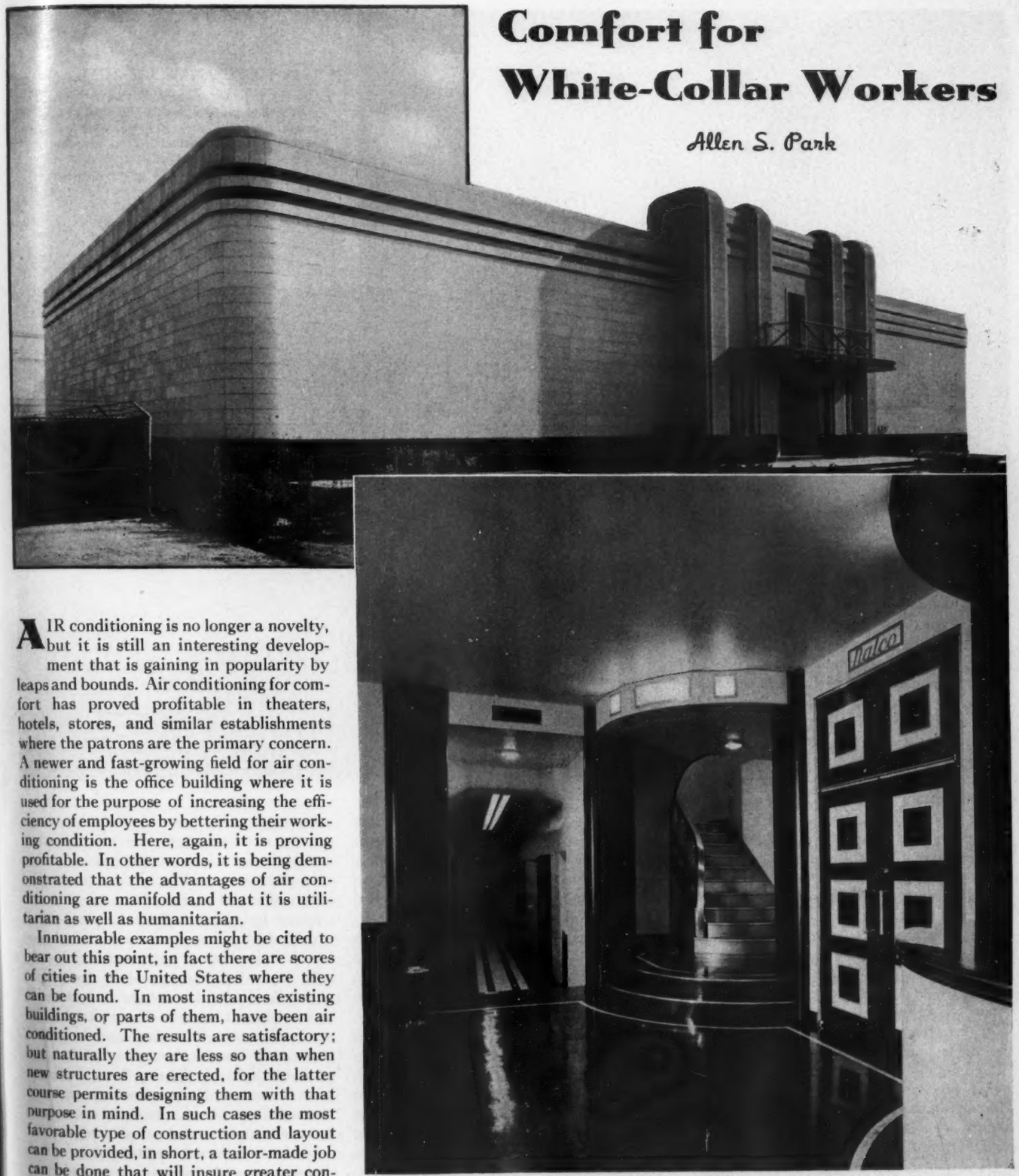
In the Laurentians, a Canadian Switzerland—a winter playground for Eastern Canadians and their friends and guests—has taken form and is rapidly growing. The combination of elements is unique, for nowhere else in America is there to be found such an unspoiled expanse with dependable climatic conditions and unparalleled facilities within easy rail reach by thousands of people both from the Dominion and from the United States. Though long and widely known as an area of recreation and sport, skiing has brought it into its own as a region of all-year-round enjoyment with pleasures and profits for many. It will undoubtedly continue to develop in both respects and, as regards skiing, to establish itself more firmly as the Switzerland not only of the eastern provinces but of the eastern states.

LUNCH ALFRESCO

After a few hours of strenuous exercise, the innerman cries out for sustenance. One of the most satisfying ways of answering the call is to cook a hot meal over a fire in the woods.

Comfort for White-Collar Workers

Allen S. Park



EXTERIOR AND ENTRANCE LOBBY

This air-conditioned windowless structure is of two stories and measures 135x100 feet. Its 15-inch-thick masonry walls are sheathed with terra cotta. All exterior noises are excluded, and floors are covered with sound-deadening material.

AIR conditioning is no longer a novelty, but it is still an interesting development that is gaining in popularity by leaps and bounds. Air conditioning for comfort has proved profitable in theaters, hotels, stores, and similar establishments where the patrons are the primary concern. A newer and fast-growing field for air conditioning is the office building where it is used for the purpose of increasing the efficiency of employees by bettering their working condition. Here, again, it is proving profitable. In other words, it is being demonstrated that the advantages of air conditioning are manifold and that it is utilitarian as well as humanitarian.

Innumerable examples might be cited to bear out this point, in fact there are scores of cities in the United States where they can be found. In most instances existing buildings, or parts of them, have been air conditioned. The results are satisfactory; but naturally they are less so than when new structures are erected, for the latter course permits designing them with that purpose in mind. In such cases the most favorable type of construction and layout can be provided, in short, a tailor-made job can be done that will insure greater convenience to occupants and superior and more economical operation of the air-conditioning apparatus.

The home of the offices and laboratories of the National Aluminate Corporation in Chicago is such a structure. This concern produces water-treating chemicals: it specializes in materials for the treatment of feed water for locomotives and stationary boilers. The building is in Chicago's Clearing Industrial District and was completed three years ago. It is windowless, two stories high, and 100x135 feet in plan dimensions. Its exterior walls are finished with white terra cotta, with decorative colored bands running horizontally. The entrance is artistic, and the entire structure of typically modern architecture reflects conservatism and good taste. It is located on a spacious, landscaped tract; and a feature that is appreciated especially by the working force

EXECUTIVE OFFICES

The president's office is illustrated below. The other picture shows the conference room. On the shelves are displays designed to demonstrate the beneficial effects of the company's products for the treatment of water and other purposes.

is the ample parking space for automobiles.

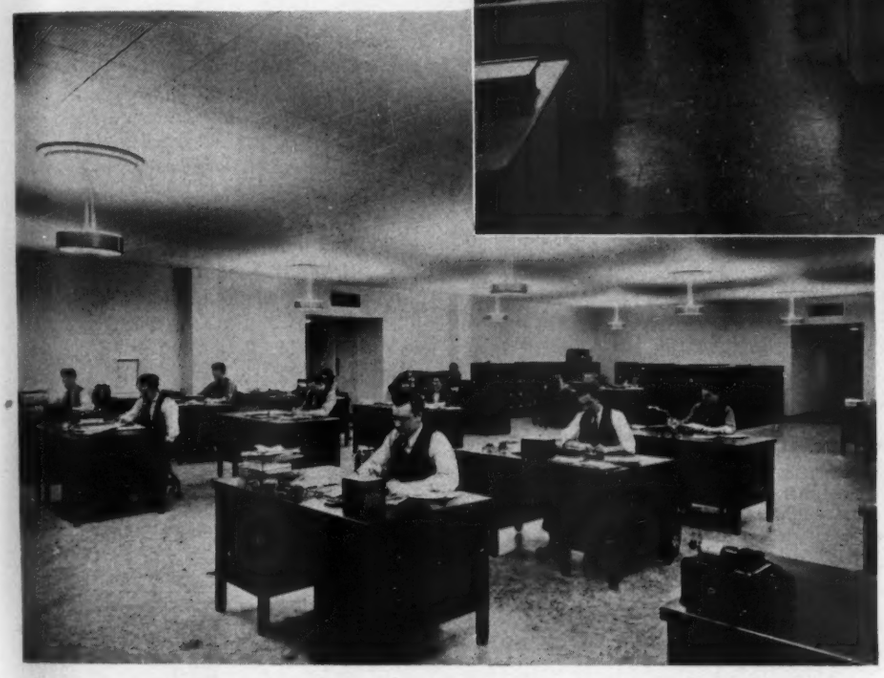
The reference to this building as a home was made purposely, for the management considers it the abode of the employees during their working hours and is endeavoring to give them comforts comparable to if not better than those that they enjoy in their own dwellings. Its motive in doing this is not entirely philanthropic, for it believes that the company will be the gainer if conditions are so favorable that everyone will be able to do a good day's work. To this end it has erected a structure free from distracting noises and with a controlled atmosphere that can be varied to suit the occupants. The home idea was carried further by providing a modern lunchroom and a recreation room. For those who bring their own lunches there are facilities for making coffee, and even entire meals can be prepared. A large refrigerator is installed for storing perishable foods; and dishes are available for those who wish to cater to their own culinary wants. The building also contains a well-stocked library of reference books, and this room is fitted out with comfortable chairs where one can relax while reading.

Prior to the construction of the building, the office and laboratory personnel was housed in different parts of a group of buildings in which manufacturing also was done. The neighborhood is an industrial one, with a variety of noises from factories, trucks, locomotives, and airplanes. In addition to the noise nuisance, smoke, dust, and odors came in through the windows. All in all, the conditions were anything but conducive to efficient office and laboratory work.

For those and other reasons a windowless structure was decided upon. To begin with, the view from the windows of the plant was unattractive, and they had to be kept closed most of the time to keep out the noise, smoke, dust, and hot or cold air. It is more difficult and more expensive properly to temper the air in a building with than without windows. They admit heat in summer and cold in winter, thereby increasing the cooling or heating load, and they interfere with humidification in winter because of moisture condensation. One of the chief purposes of windows is to let in light. Because of changing conditions, interior spaces are frequently too sunny or too dark, and uniform lighting is impossible with them. To benefit from natural light it is necessary to construct long, narrow buildings and to provide courts or wings to expose as much of the wall space as practicable to the outdoors. A windowless structure with artificial lighting, on the other hand, can be in the form of a solid rectangle or a square. This effects savings in construction amounting to approximately 20 per cent and considerably lowers the cost of air conditioning by eliminating heat gains and losses through windows and by reducing the length of the air ducts. The true effect of windowless architecture can be realized when it is stated that in the case of this adequately insulated building it is calculated that the heat required for comfort could be supplied in −10°F. weather solely by the electric lights if it were not necessary to bring in outside air for ventilation.

The illumination in the building closely approximates daylight and has the advantage of remaining uniform, whereas when actual daylight is depended upon the light intensity varies widely as the sun changes its position and is alternately exposed and covered by clouds. Artificial daylight is provided by indirect fixtures in which yellowish incandescent light and bluish mercury-vapor light are mixed in the proper proportions. An alternate procedure would be to subtract some yellow light through the medium of a blue glass, but this would result in a loss of about one-third of the available light. A lighting intensity of at least 20 foot-candles was decided upon, and this is sufficient to eliminate the use of local sources of light such as desk lamps. The brightly illuminated rooms lend an air of cheerfulness and also make for speedy and accurate work. Furthermore, the ultraviolet rays from the mercury-vapor lamps are conducive to healthfulness.

The structure is divided into 63 spaces, including a large general laboratory, several smaller laboratories, a spacious general office, numerous smaller offices, corridors, etc. The occupants of these rooms do not all desire the same temperature conditions. Moreover, the amount of heating or cooling required to maintain a given temperature



NO AUXILIARY LIGHTS

Lighting is of sufficient intensity to obviate the use of desk and other auxiliary lamps in the general offices and laboratories. The latter have facilities for exhausting fumes through the roof so that recirculated air will not be contaminated.

is not the same in all of them because of variations in heat attributable to lighting and because the laboratories contain large heat-producing devices that are in operation a good part of the time. The heat given off by these as well as by the occupants makes it necessary to cool certain spaces even in winter.

In view of these considerations it was desirable to provide an air-conditioning system that would meet the variable temperature demands of the occupants and that would either heat or cool the individual rooms, depending upon the uses made of them and upon the outside temperature. It was also necessary, of course, to ventilate the building whenever it was occupied and to equip the laboratories for the emergency exhaust and isolation of fumes resulting from experiments or from the accidental spilling of volatile chemicals.

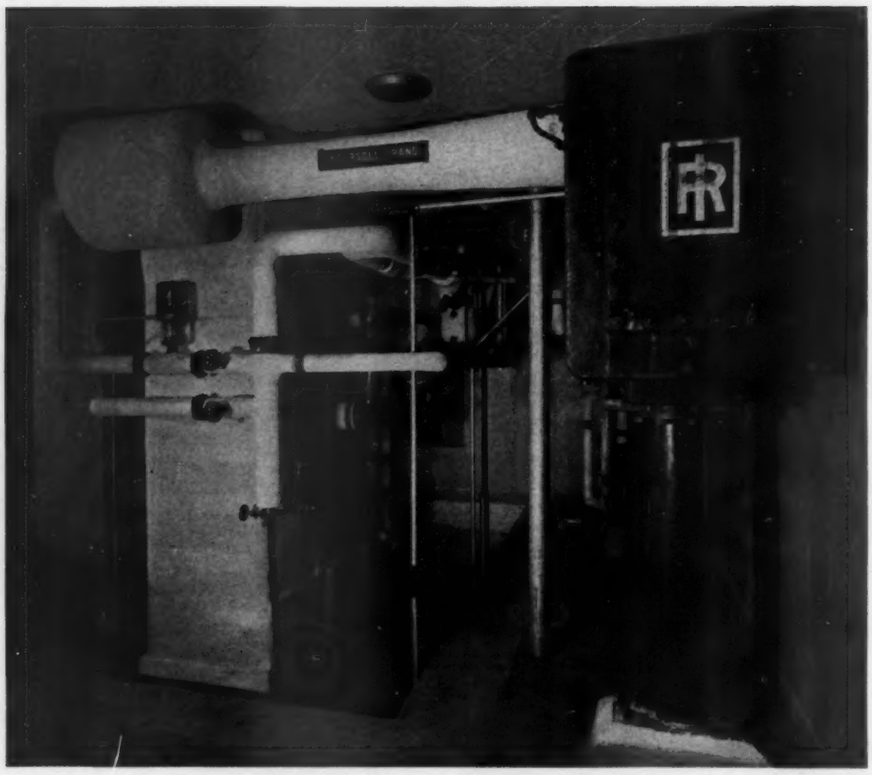
To accomplish these aims, branch air ducts extend to each of the 63 spaces, and each duct contains a cooling coil and a heating coil. These ducts are supplied with air from a main duct, and this air can be made up entirely of either outside air or recirculated air, or of any desired mixture of the two. Heating coils are provided for tempering outside air when this is required. The air to be circulated is passed through automatic oil filters, humidified in winter, and is then blown from the main duct to the branch ducts. The conditioning is done by two practically identical systems, each of which serves approximately one-half of the structure. These two systems are cross-connected, and in case of an emergency either one can take care of the entire building with a fair measure of efficiency.

The outlets of each duct are at or near the ceiling of the space it serves. Air intended for recirculation is withdrawn through grilles at the floor level and is conveyed to basement trunk ducts through chases in the outside walls that are insulated with ½-inch corkboard and through sheet-metal ducts in the interior walls or partitions. The latter, together with all doors, are made tight for privacy and to localize noises, and if more air is admitted than is returned for recirculation, the excess cannot pass from one room to another. It is vented to spaces in the ceiling and withdrawn from them by suction fans on the roof. Rooms with fume odors are connected by ducts to a roof fan that exhausts the full volume of entering air. In winter, all spaces are heated entirely by the circulated air, there being no radiators.

The heating and cooling coils in the ducts are supplied with hot and cold water, respectively. The water is heated by steam in a shell-and-coil-type heat exchanger, steam being admitted as needed to keep the water at a temperature of 160°F. This is done by means of an aquastat that is in the water and that controls a throttling valve in the steam-supply line. The hot water is pumped through the heating coil in each duct, the flow being regulated by a throttling valve that is controlled by a thermostat in the room serviced by that particular duct. Water for the cooling coils was originally obtained from two 300-foot wells and was pumped to the coils at a temperature of 53°F. Recently, however, the flow of the wells decreased to such an extent that it became necessary to use city water, first cooling it to the required temperature.

After a careful study of the various methods available for chilling water, an Ingersoll-Rand steam-jet, water-vapor refrigeration unit was chosen and a machine rated at 55 tons of refrigeration was set up. This cools the water taken from the city mains at approximately 60°F. to 45°F. The chilled water is pumped to the cooling coil in each air-supply duct, the amount admitted being controlled in the same manner as already described in the case of the hot water.

The steam-jet unit utilizes water as the refrigerant. By pulling a sufficiently high vacuum on the water, its boiling point drops below its normal temperature, in this case 60°F. This causes some of the water to flash into steam. In doing this, it extracts heat from the remaining water, thereby cooling it. This takes place in an evaporator, from which the chilled water is withdrawn as required to supply the cooling coils. In passing through these, the water takes up heat, and is then returned to the evaporator where, because of its higher temperature, a portion of it instantly vapor-



STEAM-JET REFRIGERATION UNIT

This machine supplies chilled water to the cooling coils of the air-conditioning system. Inasmuch as it utilizes only water as the refrigerant there can be no hazard from escaping gas, making it entirely safe for use in an office building. This unit has a rated capacity of 55 tons of refrigeration. It cools water taken from the city lines at approximately 60°F. to 45°F.

izes and has the desired cooling effect on the water in the evaporator. The vacuum is maintained by steam-jet boosters. There are two of these, each one of which serves a separate evaporator compartment, an arrangement that permits varying the output of the machine by using either one or both compartments, according to the demand for chilled water.

Operating steam, directed into one end of the steam-jet booster through high-velocity nozzles, withdraws the vapor by aspiration. The vapor and steam then pass through a venturi-shaped tube, where the velocity is converted into pressure. The mixture is thus compressed to a lower vacuum and is discharged into a surface condenser, where it is liquefied. The condensate is collected and returned to the boiler by a pump. A single-element, 2-stage, steam-jet air ejector serves as a vacuum pump to maintain a vacuum in the condenser and to remove air and other non-condensables that leak into the system. The water that is circulated through the condenser to cool and condense the steam-vapor mixture is afterward used in process work in the company's manufacturing plant.

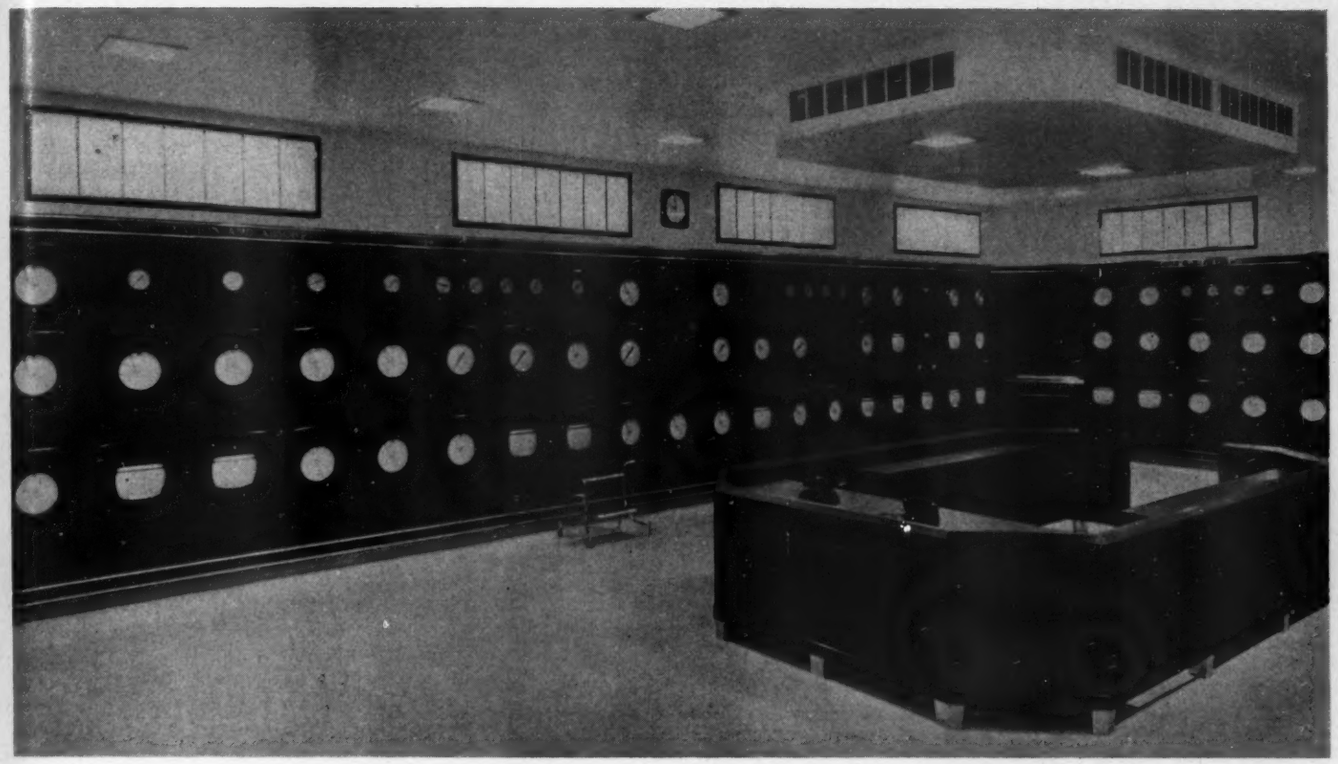
The occupants of each of the 63 air-conditioned spaces can actually order the temperature they desire by merely setting the thermostat at that point. As already stated, the thermostat controls valves in the water supply to the hot- and chilled-water coils in the duct that leads to that particular room. When the latter is colder than the temperature setting of the thermostat, the hot-water valve opens. When the room reaches the specified temperature, the heating valve remains throttled in the position corresponding to that heat. If the room temperature rises above the thermostat setting the heating valve closes, and if the room temperature continues to be too high the cooling valve gradually opens.

As previously mentioned, the heat given off by the lights varies in different parts of the building. Corner rooms on the top floor need more heat in cold weather than the lamps furnish. There are, however, many interior spaces with no outside exposure that have to be cooled in all seasons. In the general laboratory on the first floor the heat from lights totals 67,300 Btu's per hour, and the heat loss to the outside in −10°F. weather is only 18,705 Btu's per hour. Respective figures for the general office, which is on the top floor, are 45,600 and 32,210 Btu's, and for an individual office on the same floor they are 4,600 and 3,900 Btu's.

The walls of the building are of 15-inch-thick masonry, with 2-inch furring strips and metal lath and plaster. The roof is made up of concrete joists, with 2½ inches of concrete between them, 2 inches of corkboard, and a covering composed of tar and gravel.

THERMOSTATIC CONTROLS

Some of the control units which, when actuated by thermostats in the various rooms or spaces in the building, admit hot or cold water to the coils in such quantities as are required to maintain the temperatures desired by the occupants.



STANDING GUARD IN AN OIL REFINERY

This view of the control room in a modern oil-refining plant illustrates the extensive use the petroleum industry makes of instruments of measurement and control in its processing. Even more significant, it shows the efficient centralizing in one room of the measuring and control instruments for processing equipment, no matter where located in the extensive plant. Pneumatic transmission systems make possible this centralizing which, in turn, makes possible the easy and constant cross-checking of one process condition with another, as well as continuous supervision of the entire plant's operation.

Pneumatic Instruments for Automatic Control

J. B. McMahon*

OUT on the coastal plain of the great Southwest there stands a typical oil refinery. The night looks down on towering stills and a maze of pipe lines, shining silver-white in the glare of innumerable electric lights. The word "enormous" describes the plant in every aspect—its sprawling extent, the size of its structural units and equipment, the investment of money it represents, the value of its products, finished and in process. There are relatively few men to be seen, but at key points in the jungle of piping, automatic control instruments are silently, vigilantly on duty. In each of them a tiny jet of air is escaping, a jet with scarcely the force to flicker a candle-flame.

Somewhere in the enormous plant process temperature rises, ever so slightly; and in one of the control instruments that tiny jet of air is checked. Somewhere else a great valve is moved, ever so slightly; a flow of steam is reduced; and the measured temperature returns to precisely its proper point. The pen of the controller makes a little jog on its chart record; and that is the whole written history of how the value of thousands of gallons of gasoline was momentarily endangered, and of how a tiny jet of air came to the rescue.

Numerous other examples of air at work in the control of vital processes might be found in the great industrial plants that line the Atlantic seaboard, and many of which are importantly involved in our program of national defense. It is literally true of some of these plants that they could not operate effectively, could not carry out their intended purposes, without instruments of automatic control. The complexity of the operations that man has devised and mechanized is beyond man's own power to control efficiently.

The development of industrial instruments is not an independent and separate phenomenon but is an integral part of the progress of industry. As industrial processes have improved, whether their increased efficiency is expressed in terms of speed, productivity, economy and ease of operation, or by the value of their production, the need for more and better instrumentation has kept pace. The term "industrial instruments" is a broad one. Any process in industry in which there are variable factors presents a need for methods of measurement, and for these varied needs there exist many different and appropriate measuring implements. In this discussion we shall consider only those that employ compressed air as their operating medium (and it may be well to give warning, here, that this discussion will be elementary and non-technical, even at the risk of raising objections from literally minded engineers). We can further limit our field by skipping, for the present, those instruments that employ air in their measuring operations, but which do no controlling; and thus we isolate one specific group of industrial instruments for our consideration—air-operated automatic controllers.

To begin any study of process control, two basic principles should be stated: before any variable can be controlled it must be measured, and there can be no control without restriction. The most common

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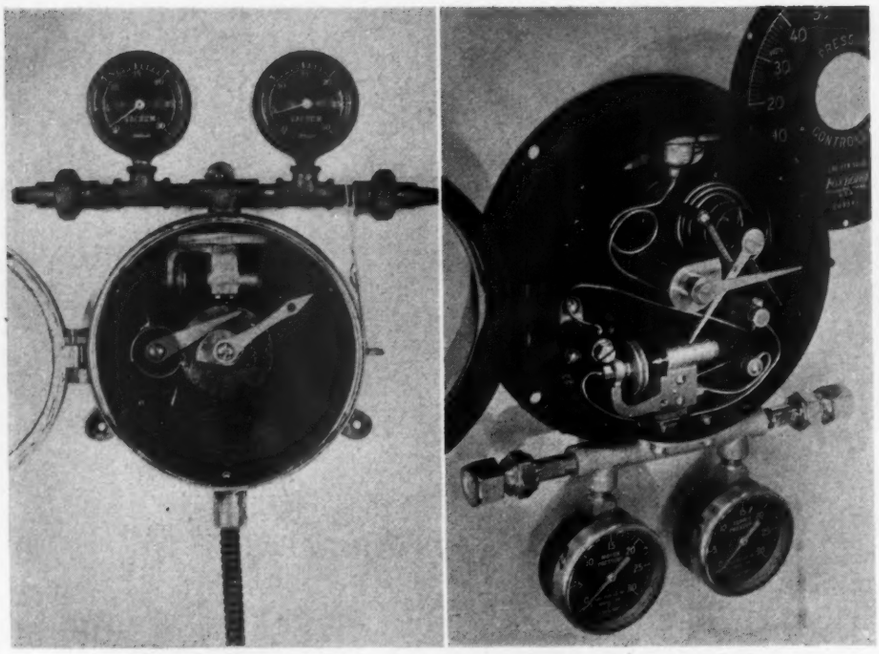


FIGURE 1

An early pneumatic controller (left) and its modern counterpart, the Type 1105, which is of practically the same design and based on the same principles. Paper mills were among the earlier users of automatic control instruments; and as all of them employed vacuum in making paper, and all did not have compressed-air systems, the first Foxboro controllers were vacuum operated. The drawing at the bottom of this page shows in diagrammatic form the elements contained in the Type 1105 controller.

variables encountered in industrial processes are temperature and pressure, so common, in fact, that they are practically universal. There is probably no industrial plant anywhere, large enough to be thus identified, that does not have in its boiler room at least a thermometer, a liquid-level gauge and a steam-pressure indicator. And throughout the plant, applications will be numerous of processing temperatures and pressures. After these first two variables comes a larger secondary group, by no means secondary in importance but, rather, because they are of greater or lesser importance, or of no importance at all, in certain industries than in others. In this secondary group might be mentioned humidity, liquid level, rate and volume of flow, time, motion, acidity or alkalinity, and similar qualities and conditions.

It must be remembered that the prime purpose of any instrument is measurement, and any other service the instrument performs either follows or accompanies the measuring process. Thus an "indicator" shows, by the movement of its pointer across a calibrated dial, the measurement taken, while a "recorder," equipped with a pen and a calibrated chart, makes a written record of the measurement. A "controller" may be of the indicating type or the recording type, but before it can control anything it first must measure. For the controlling medium, the majority of control instruments employ either air or electricity, and each of these two types has certain characteristics that are favorable in certain applications. In a certain percentage of cases, either type might be entirely satisfactory, and the prospective purchaser, in making his decision, would consider these advantages of the air-operated equipment:

Air-operated control is infinitely flexible. In electrically operated systems there must be a separate contact and circuit for each successive point at which control may be desired, and between these separate contacts, however closely established, there must be intervening spaces. Progressive control, therefore, is by means of a number of successive steps, while with air-operated control there can be infinite shading from one control position to the next. Most industrial plants have compressed-air lines running throughout the buildings, and thus the operating medium is as conveniently available as electricity. The operating expense of electric control equipment is so slight that it is hardly worth while to mention the even lower operating cost of pneumatically operated instrumentation.

Air-operated systems have the advantage of simplicity. Any good mechanic can be shown how to install and service air-operated equipment. Furthermore, it is entirely safe to handle; there is no risk of shocks or short circuits. Air-operated equipment can be used safely in hazardous atmospheres, with no risk of sparks. (The petroleum refining industry uses air-operated instruments wherever such hazards exist. Out in the field, where compressed air is not always available, natural gas from the well or pipe line is frequently used as the operating medium.) A pneumatic system permits better protection against loss of control in case of supply failure. If the electric service is interrupted, there may be a critical interval of a moment or two before manual control takes over; whereas in pneumatic systems, there is always at least a small reserve supply of air for just such emergencies. Industry needs control systems of both types and both are used extensively,

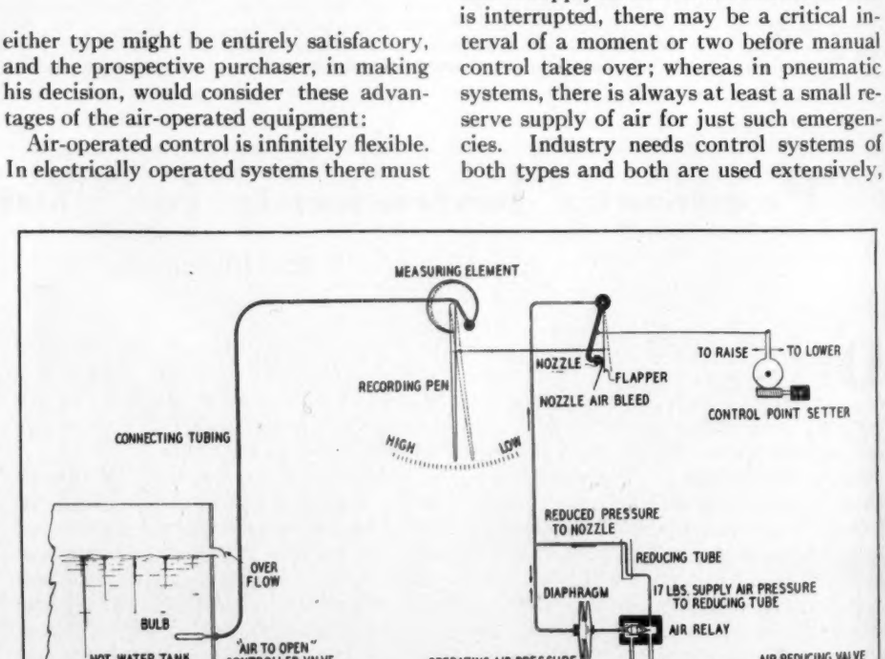


FIGURE 2

This schematic diagram, illustrating the mechanism and operation of an automatic temperature recorder-controller, is explained in the accompanying article. It will be apparent that the sketch is not drawn to scale; and, actually, all the mechanism units above the two small gauges are contained within the case of the instrument, as shown in the right-hand picture at the top of this page.

according to the circumstances of each installation. But the favorable points that have been mentioned will explain why manufacturers and users, alike, are somewhat partial to instruments of the pneumatic type.

The earliest instruments in the pneumatically operated class were of the two-position or "open-and-shut" type, and it is an interesting fact that the basic principle employed in the first Foxboro controllers is still employed today and in virtually that same manner not only by that company but by others as well. Moreover, one of the controllers in the current Foxboro line employs a mechanism which, except for refinements, is virtually the same as was first used in 1913. In an accompanying illustration, Figure 1, these two instruments are shown: an old-timer, one of Foxboro's first few, sold in 1914 to a paper mill, where it rendered faithful service until it finally gave way to an instrument of newer design; and with it, its modern counterpart known as Type 1105. (It will be observed that the two small gauges on the antique instrument read "Vacuum." Vacuum, of course, is a force, the opposite of pressure, and was employed as the operating medium in the first Foxboro controllers.)

Because of the simplicity of its mechanism, the Type 1105 instrument (and the old-timer, too, for that matter) provides a convenient example for the explanation of a controller's operation. But before we explore this subject, let us examine Figure 2, a diagrammatic sketch of an automatic control system, complete, although in its simplest terms. At the left is seen a "bulb" installed in a tank the temperature of which is to be controlled by the operation of a valve in a steam line. Capillary tubing connects the bulb with a hollow helical spring, inside the controller, and the whole thermal system of bulb, tubing and spring is completely filled, usually with a special liquid and its vapors, forming a highly expansible fluid. As the temperature in the tank rises, the increasing vapor pressure exerts force which, being restrained at all other points, tends to uncoil the spring, just as a garden hose tends to uncoil when the water is turned on. When the tank temperature drops, the spring resumes its normal, carefully predetermined shape. (The indicating pointer or recording pen, being fixed to the axis of the spring, is moved in accordance with the spring's movement. The measuring operation, plus indicating or recording, is thus completed; but the controlling operation has not yet been explained.)

Beneath the 1105 Controller will be seen two small gauges, which will be identified in that part of the diagram where the control mechanism is shown (in exaggerated scale). The gauge at the right shows the pressure in the compressed-air line, the air passing through a filter and a reducing valve and then into the instrument. (The usual operating pressure for Foxboro controllers is 17 pounds.) Another air line, leaving the instrument at the opposite side, runs to the "air motor" of the controlled valve, and the small gauge at the left indicates the pressure in this line.

The mechanism of the controlled valve (shown in Figure 3) includes a carefully calibrated spring of sufficient force to hold the plunger of the valve in the "closed" position. However, opposed to this spring is a diaphragm of flexible material, and when this diaphragm is inflated, its force is sufficient to overcome the force of the spring, and the valve plunger is moved to the "open" position. Thus, whether the valve is closed by the spring or opened by the diaphragm depends on whether air is admitted to the diaphragm to inflate it. This type of valve, known as "air to open," is most generally employed, so that the valve will be closed by the spring in case of any possible failure of the control system. By reversing the direction of the forces exerted by the spring and the diaphragm, the valve becomes "air to close."

Now, if we turn again to the photograph of the 1105 Controller (Figure 1), the control mechanism can be explained and traced in exaggerated detail in the diagram (Figure 2). The dial of the instrument has been removed. In operation, the pointer is set at the desired control point. that is, the temperature (as shown on the dial) that is to be maintained in the tank. It will be seen that as the pointer is moved its cam is rotated, and the lever which bears upon the cam is positioned accordingly. This lever, being fixed to the shaft of the helical spring, adjusts the spring position and, in turn, the position of the light, rigid strip of metal extending downward from it. This metal strip is the "flapper," and its position, relative to the "nozzle," determines the freedom with which a tiny jet of air from the nozzle is permitted to escape. The unit inside the bottom of the case is the air relay. Its essential mechanism is a tiny air valve, opened or closed by the movement of a plunger which, in turn, is moved by a small metal diaphragm. When the measured temperature in the tank is below or up to the control-point setting, the valve in the control relay is held open, and the incoming compressed air reaches the nozzle (at greatly reduced pressure) and escapes. So long as the nozzle bleeds air, compressed air is also supplied to the valve motor in the stream line and it inflates the diaphragm and holds the controlled valve open. But when the tank temperature rises, this is what happens: the filling of the thermal system expands, causing the helical spring to move, which brings the flapper up against the nozzle and shuts off the jet of air. Thus, back-pressure is built up, which expands the metal diaphragm, which closes the tiny valve in the air relay. The compressed air is no longer supplied to the controlled valve in the steam line, and the air in its diaphragm escapes, allowing the spring to close the valve.

It is hardly necessary to say that all this action takes place instantly, and not in the leisurely manner in which it has been explained here. But it may be necessary to point out to those who are unfamiliar with the subject that this is the simplest possible explanation of the simplest type of control mechanism. Those for whom this explanation has been tediously elementary are at liberty to turn their attention to Figure 4, in which is revealed the mechanism of a Foxboro pneumatic ratio flow receiver with Stabilog recording controller. At least the air relay is identifiable, at the bottom of the case; and concealed behind the recording pen there is a nozzle from which comes a tiny jet of air like the one whose somewhat simpler environment has just been described.

About 65 per cent of the ordinary in-

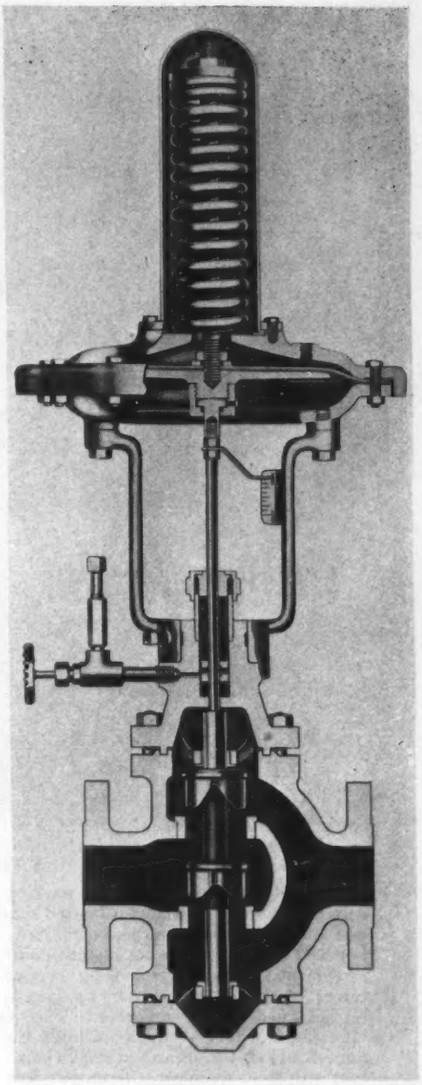


FIGURE 3

The Foxboro Stabilflo valve shown in this cut-away drawing is of the air-to-close type. The flexible diaphragm of the air motor is seen extending from rim to rim of the diaphragm chamber below the calibrated spring. As there is no air pressure on the diaphragm at the moment, the spring has raised the plunger, opening the valve.

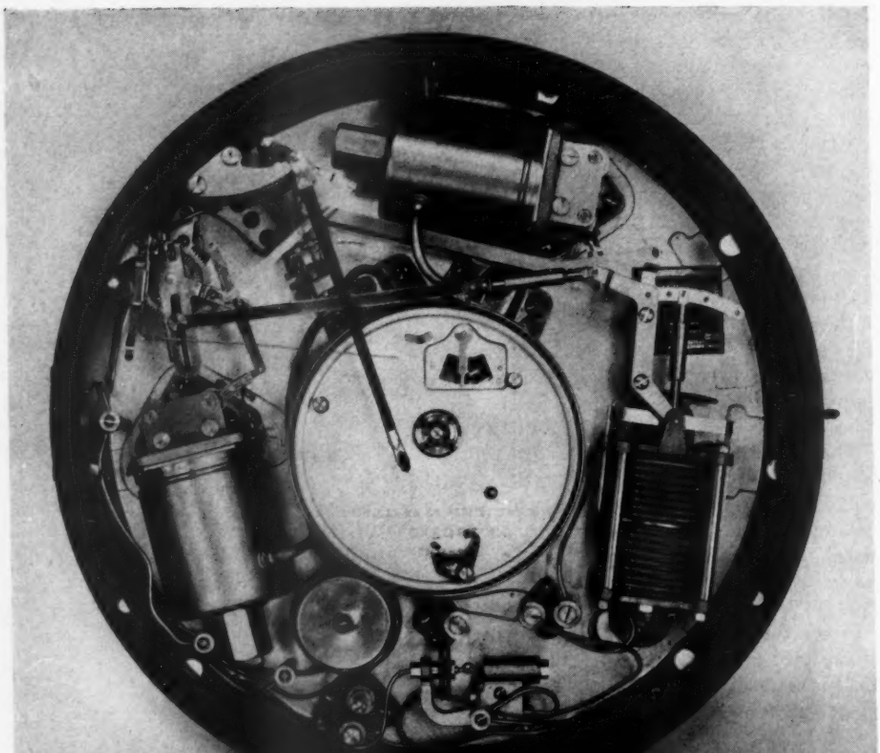


FIGURE 4

A complete explanation of the working principles of this pneumatic ratio flow receiver is impossible, within a limited space, but parts of the mechanism can be identified and their general purpose explained. This instrument maintains the desired ratio between two flows, at some distant point. The two cylinders are part of the pneumatic system by which the two measurements are continuously transmitted to this receiver. A chart record of the two flows is made by two pens (one of which happens to be concealed behind the other). The Stabilog control unit at the right includes two opposing hydrons, or metal bellows, the movements of which, according to the requirements of the measured conditions, provide the pneumatic control for the distant valves to maintain the proper flow ratio. The large, round case in the center contains the clock that revolves the chart.

dustrial control problems can be handled with complete satisfaction by open-and-shut controllers, but there remain about 35 per cent of the applications in which, because of the complexity of the process, or the presence of such troublesome factors as "process lags," proportional or "throttling" control is required. To make this distinction clear, let us resort to strictly non-technical and somewhat inaccurate definitions, as follows: Open-and-shut control is two-position control: the controlled valve is either "open" or it is "shut." In throttling control (so long as the process is continuing) the valve is never completely open or completely shut, but "throttles" the controlled fluid by being in some position between "open" and "shut."

One who is not familiar with instrument engineering may be led into erroneous thinking as to when open-and-shut or throttling control is more suitable, and how to determine the choice. There are no simple or hard and fast rules: the nature of the process and its equipment determine the type of control that is most suitable. Whether the product of the processing is commonplace or unusual does not matter in the least. Two examples may illustrate this point: the manufacture of rayon is a process in which textile thread is eventually and almost magically produced from a combination of cotton linters and pulp, and open-and-shut controllers are used almost entirely. By contrast, the pasteurizing of milk would seem to be a simple process, yet most of the continuous-type pasteurizers employ throttling control.

The throttling range of the first throttling controllers made by the Foxboro Company, about 15 years ago, was 4 per cent of the scale. And again, by describing an old-time instrument we can simplify the explanation of how the same principles are employed in similar modern instruments. Suppose, for the sake of simplicity, that our controller has an evenly graduated scale range of 0° to 100°F., and that for a certain process we desire to maintain a temperature of 50°F. Our control point is exactly in the middle of the scale. From two degrees above that point to two below it (52° to 48°), constitutes a band of four degrees which, in the early models, was the throttling range—4 per cent of the scale range, whatever that scale range might happen to be. Between 0° and 48° the heating valve was fully open, and if the valve required 16 pounds air pressure to open it, the full 16 pounds was being applied. But this pressure began to shade off as the process temperature reached the throttling band. At 50° only half of the 16 pounds pressure was on the diaphragm, and the valve was only half open. At 52° there was no air pressure at all, the spring closed the valve, and it remained fully closed when the temperature was at any point between 52° and 100°.

The standard throttling range in Foxboro controllers was soon increased to 12 per cent of the scale range, but today there are certain Foxboro instruments that have a throttling range as high as 3000 per cent —which merely means that full-scale deflection of the instrument's pointer will produce only about ½ pound change in air pressure, or one-thirtieth of the full pressure available in the supply line. Whatever additional change may be necessary is provided by an "automatic reset" feature of the controller, which slowly increases the air pressure on the valve motor to the proper amount. But circumstances may require still more of the controlling system, particularly for applications where there are radical process changes. For such applications there has been developed a type of instrument which overcomes the inherent "drift" of throttling control. This instrument, known as the Stabilog controller, also a product of The Foxboro Company, was the first controller to be made with automatic reset of the control point. It has all the throttling features that have been mentioned, plus a mechanism for resetting the control point to the index, to keep the changing process conditions in proper balance.

But the choice of the proper control instrument is not the whole secret of control engineering. In planning the instrumentation for process control, it is necessary to follow through the whole control operation and to provide a valve that will function correctly, as well as a suitable instrument to actuate the valve. This means that a valve of proper design is essential, for it is fundamentally necessary, for accurate control, that for a certain percentage change in the process balance there shall be an equal percentage of change in the valve port area. This result will be obtained only from a scientifically designed controlled valve. The necessity of correct valve design is so fundamental that perhaps this further word of explanation should be added: Any change in the position of the pen or pointer must have resulted from a percentage of change in process conditions. Therefore, it is obvious that a corresponding percentage of change must be made in the controlled flow, if the desired process conditions are to be restored and kept constant. Every time the pen moves one space on the chart, the operator expects a

corresponding definite increment or decrease of air pressure on the valve motor. When the pen moves another space, another and equal change in pressure should be expected. But, if the valve is not correctly designed to have true exponential characteristics, with percentages of change correctly and correspondingly balanced, the desired performance becomes an impossibility.

Because of the fixed principles that enter into control engineering, and the fact that control problems do yield to solution through correct analysis and study, we are accustomed to speak of the "science of control"; but actually it is still an art and not yet a science. Our knowledge of the subject is based on broad and varied experience, but the mathematical foundation for a "science" is still uncompleted. Substantial progress has been made in the past few years in this direction, but the work is no assignment for the amateur: it furrows the brows of the best physicists and mathematical experts. One obstacle encountered is the inability of the human mind to think in terms beyond the simple terms of evident cause and evident effect. A simple problem of this kind, for which the mind confidently supplies the customary answer, becomes infinitely complicated when the factor of time is injected into the equation.

Let us diagram a very simple control problem for an example of this. In Figure 5, three connected tanks, of equal diameters, are represented, with water pouring into the first one and out of the third. The three orifices, 0_1, 0_2, 0_3, and all the pipe diameters are such that the outflow of water equals the input. Notice, first of all, that, because of restriction at the orifices and friction encountered in flow, the water establishes itself at different levels in the three tanks—although the flow is the same at all points of flow. Now, let us increase the volume of input by 20 per cent. What will the new levels be in the three tanks, and how long will it take the tanks to reach the new balanced condition? What is the mathematical formula for these changes, and what will the formula be if the input is increased 21 per cent instead of 20 per cent? Suppose we reduce the diameter of tank B by one-half. What will happen then to the levels, and to the flow —and how soon will these changes occur?

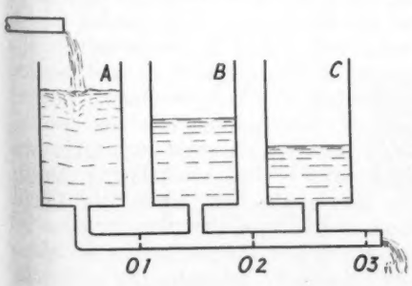


FIGURE 5

The hypothetical process represented by this simple diagram is described in the accompanying article. The three tanks are all of the same diameter; the outflow of water equals the input; and at the beginning of the experiment the rate of flow is the same at all points of flow.

AIR SUPPLY FOR INSTRUMENT OPERATION

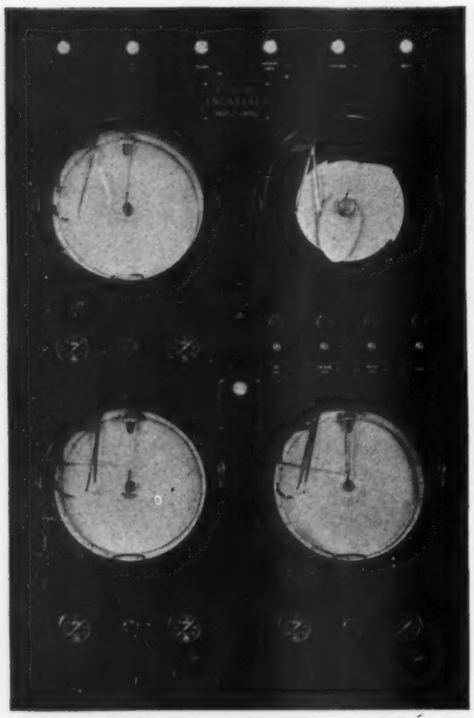
In large plants, compressed air for the operation of the instruments is ordinarily taken from the regular supply lines; but a small unit is frequently provided for standby or emergency use. Shown here is an Ingersoll-Rand Type 30 air-cooled compressor for reserve service in a large oil refinery.

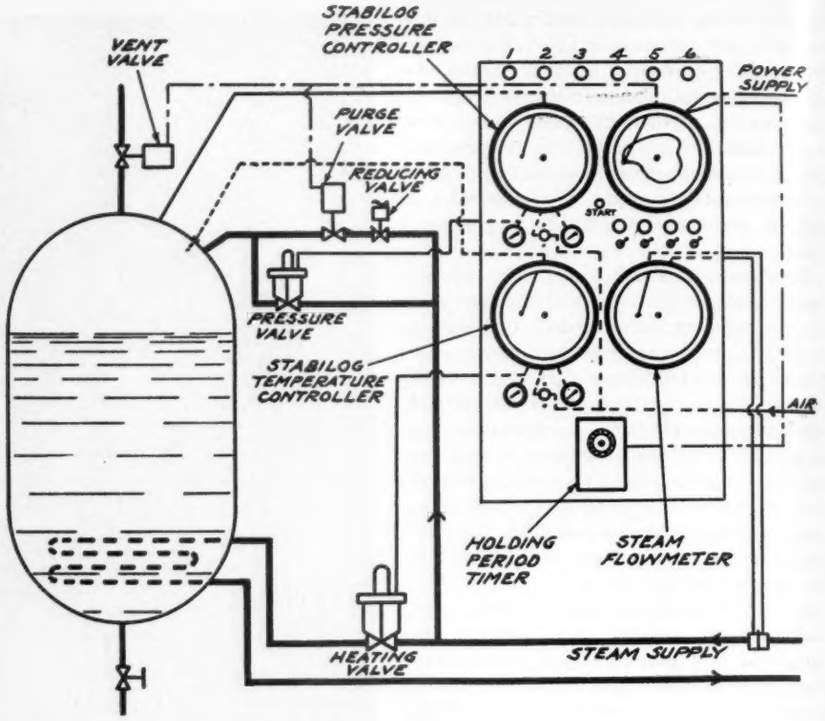
One of the principal companies engaged in the manufacture of industrial instruments has, in its laboratory, an elaborate hook-up of tanks, piping, orifices, valves, by-passes and other apparatus, which permits making studies of experimental problems of many kinds in the fields of pressure, level and flow. The routine is to set up certain predetermined conditions for a test, and establish balance at all points: then upset the balance at one point and try to estimate how long it will take for the changed conditions to establish themselves in new balance—and what the new balance will be!

Much work is still to be done by the slide-rule experts, despite the tremendous progress already made in the advancement of automatic control. Indeed, the achievements in the field of control are so diverse and so numerous, and many of them are so spectacular, that people sometimes jump to the conclusion that anything that can be manually controlled can be automatically controlled. This is not true. The fact is that a process that is easy to control by hand is usually difficult for the application of automatic control, and vice versa. The reasons are plain: the prime virtue of the control instrument is its capacity to pay unremitting attention to its job, something that is virtually impossible for a human being to do. On the other hand, if the control problem is one that calls for the use of judgment, all the instruments in the world can't supply it, but a man can.

But, short of supplying a brain to make a decision, there seem to be few requirements in the field of control which cannot be filled by automatic instruments. Consider, for a moment, one of the most familiar and widely used industrial instruments. Modern industry demanded, in addition to control, a record of process operations, and so the recorder-controller was developed. We have already seen that the same element in an air-operated recorder-controller which does the measuring also operates the control mechanism and guides the recording pen, and the three functions of measuring, controlling and recording are thus combined. Having attained this combination in the design and performance of an instrument, there would seem to be few problems beyond the scope of its capacity. And, loosely speaking, this is true, for there is almost no limit to the extent and manner in which the basic control mechanism can be amplified, modified or coupled to achieve the final result desired.

An interesting example of automatic control at work is the performance of the Foxboro time and sequence control system, consisting of the four instruments shown in Figure 6 and again in the diagrammatic sketch Figure 7. The master





FIGURES 6 AND 7

On the panel (left) are mounted the instruments used for the time and sequence control system that serves to direct the automatic operation of a process cycle. The six signal lamps at the top are lighted in turn as each successive process step is reached. The panel is shown again in the drawing at the right, and the operation diagrammed is described in the accompanying article.

instrument, at the upper right, does no recording, instead of a chart its clock rotates two eccentric cams on which two cam-followers ride. Here are the successive steps of process operation, entirely under the automatic control of this master controller and its supplementary instruments: At the first cam position *1*, the equipment is "ready to start" and the operator pushes a "start" button. The primary cam-follower drops into position *2* and the vent valve in the retort is opened and the retort purged by an inflow of low-pressure steam. At the end of one minute, position *3* is reached, the vent and valve are closed, and high-pressure steam is admitted for pressuring. As position *4* is reached, the secondary cam-follower comes into operation to hold the retort at the desired processing temperature for four hours, at the end of which time the primary cam-follower takes over once more and, at position *5*, depressures the retort. At position *6* the cycle reaches its end. The master instrument is back in the "ready to start" position, and another push of the button will repeat the cycle. In fact, if it were desirable in this particular installation, the operation could just as easily be made continuous, the retort automatically charged, its contents processed and dumped and a new charge taken in, with no touch of human control from beginning to end.

Compressed air, as an operating medium, performs another service of great value to industry, making possible pneumatic systems for the distant transmission of measurements or control. Thus the operator, or the management, is able to have constant knowledge or a record of conditions at remote or inaccessible points of measurement, or to centralize at one point the actual control of equipment units wherever located.

Still another interesting application of air at work is the pneumatic "loading" of the heavy rolls and presses used at numerous process points in the textile, paper, and other industries. The traditional method of loading, to establish the desired pressure, was by means of weights hung on levers, and this somewhat cumbersome method still is common. Hydraulic-pressure cylinders on the press roll are also employed to some extent, although this method is open to some criticism because water is a relatively non-compressible fluid, and the established pressure has a "locked-in" rather than a cushioning effect. By far the easiest, cleanest and most accurate method of loading is by a pneumatic system, in which an air cylinder at each end of the press roll maintains exactly the desired pressure, as determined by the setting of the controller, located wherever may be most convenient for the operator.

In innumerable ways, pneumatic instrumentation makes its contribution to the efficiency of industry. And industrial instruments are, indeed, deserving of respect, not only in their more spectacular performances but in their routine assignments as well. They are expected to be accurate, practically to laboratory standards, and dependable beyond human capability, despite the fact that they are put to work amid dust and dirt, steam, fumes, heat, snow, and every imaginable unfavorable condition, indoors and out of doors. It is truly a testimonial to the quality of their manufacture that they so completely meet these exacting requirements. They are sturdy, and built for work, and require surprisingly little attention and expense for maintenance. They survive accidents and abuse better than should be expected.

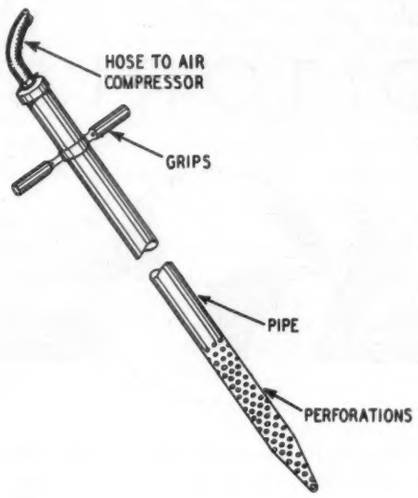
Curiously, although air provides the life-stream for a pneumatic controller, air can also be its worst foe. Damp, dirty, corrosive air, if regularly supplied it, will cause trouble eventually, for the control mechanism has considerable delicacy of dimensions, despite the man-size job it performs. The capillary tubing leading to the nozzle of the instrument has a diameter of only 8/1000 of an inch; and a bit of flying lint or air-borne cinder, or especially a particle of oil, can make trouble here as easily as it would in the movement of a watch. The tube can be cleaned, and the obstruction removed, of course, but not without interrupting the instrument's useful service. To avoid such difficulties, an air filter is always installed in the supply line, so that only clean, dry air will reach the instrument. This is done not merely because the mechanism is delicate and reasonably valuable, but rather because it is important. That word is perhaps too colorless. In many applications the controller could correctly be described only as vital, with extensive operating units and valuable materials in process dependent upon the uninterrupted operation of its tiny jet of air.

Washing Gravel with Air

MORE than 50 per cent of the gravel used on construction jobs ten years ago would today be condemned. The modern contractor now demands washed gravel for most of his work, and by "washed" he usually means something more than the ordinary action of the stream current. Along the Ohio Valley waterways, where most of the commercial sand and gravel are taken from the beds of rather sluggish streams, the quality of the product is being raised by from 20 to 40 per cent by agitating the water by means of air under pressure.

The method calls for the services of a small, portable air compressor and of a specially constructed blowpipe. The compressors used on most jobs have a capacity of 2 to 5 cubic feet of free air per minute and are operated by ⅛- to 1-hp. gasoline engines. They are generally mounted on skids so they can be quickly transferred from land to barges or to piling. The blowpipe is made from a 6-foot section of iron pipe, 1½ inches in diameter and with its lower end cut into four gores which are welded into a point. The pointed end, for a distance of 10 inches, is perforated with small holes, and the other end is threaded to take a rubber air hose 1 inch in diameter. The latter varies from 10 to 100 feet in length, depending upon the amount of cleaning that has to be done.

When operations are begun, the compressor is started and the pointed end of the blowpipe is pushed down into the gravel bed to a depth of 6 to 8 inches. Where the water over the bed is not more than 30 inches deep, air at from 3 to 8 pounds pressure is sufficient to lift and agitate the gravel and the water. When the water over and around the spot is thoroughly roiled (which is effected in few minutes), the blowpipe is inserted at a new point about 3 feet from the first one. This procedure is repeated until the particular gravel-bed area has been covered.



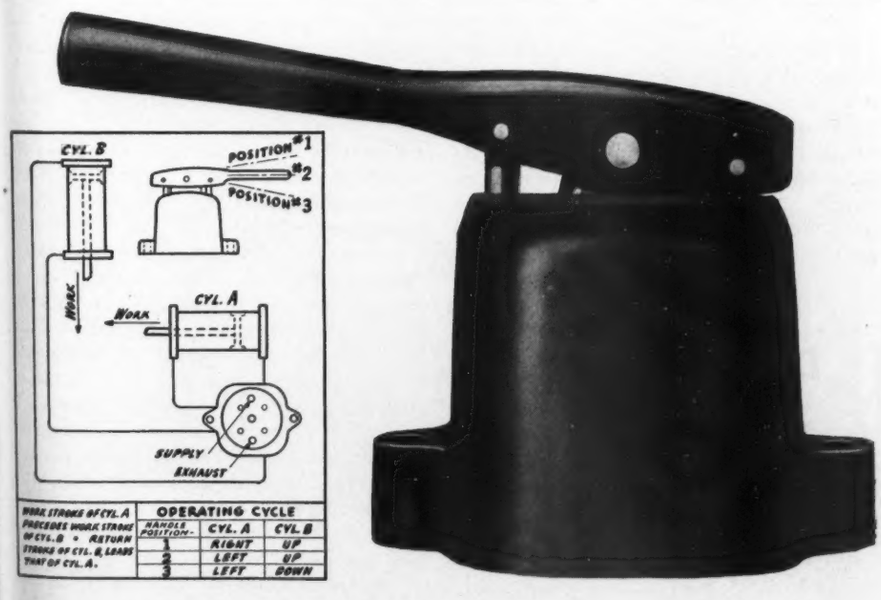
BLOWPIPE

This is made from a 6-foot length of 1½-inch iron pipe. The perforated section is 10 inches long.

When shoveling is commenced, it is found that the gravel throughout the agitated zone is remarkably free of mud, sand, and filth, and that considerable oily pigment and foreign waste has been floated out. With the cleaned area stripped, then agitation is once more resumed, the pressure being raised as the head of water increases. It is seldom necessary, except in extreme cases where the gravel is heavily impregnated with mud, to use air pressure exceeding 12 pounds.

The same practice is being carried out successfully in many locations in the production of commercial sand. A water depth or head of 20 inches is usually the limit in sand-cleaning operations because air at more than 5 pounds pressure results in waste through too violent a turbulence. In very shallow water, where there is much evidence of oil residue, air agitation reduces sand-cleaning costs by as much as 50 per cent. The work with either gravel or sand may be conducted from shore, barge, or from piling, which is generally placed in backwaters above dams.

The principle of the air-pressure method is to create, by means of agitation, cross and countercurrents of water through a gravel or a sand bed, the normal stream current invariably being in one direction. In more than 80 per cent of the cases the action has resulted in a cleaner product; and there is a saving of from three to ten cents per cubic yard in equipment and handling costs.



ONE POINT OF CONTROL

The double, hand-operated 4-way air valve illustrated here is designed to control two individual, double-acting pneumatic cylinders that lead and lag each other in their respective actions. The sketch shows a conventional hook-up when the work stroke of the first cylinder, *A*, advances before that of the second cylinder, *B*, and the return stroke of *B* is completed before that of *A*. The new valve is called Quick-as-Wink and was developed by C. B. Hunt & Son for clamps, fixtures, knives, and similar equipment operated through the medium of two air cylinders and necessitating one point of control. It is claimed to effect economies in piping and air consumption and to assure positive action.

No Slowing Down Traffic for Trucks

THE bugaboo of the motorist is the heavy truck lumbering up a grade. Caution warns him to stay behind it until he knows the way is clear, but all too often he takes a chance, endangering himself and others. To keep speedier traffic moving, the Tennessee Highway Department is experimenting with a third or slow-moving traffic lane at a point on a main highway, 15 miles north of Nashville, much used by heavy vehicles. There the road, for a distance of 6,000 feet, has a grade of from 5.5 to 6 per cent, and is characterized by a succession of curves limiting the view of the pavement.

The new lane is on the outer edge of this stretch and is 11 feet wide. To distinguish it from the others, the concrete slabs have been topped with a 2-inch layer of red concrete made by adding red iron oxide to the mix. Four pounds were used for each sack of cement at a cost of about fifteen cents per square yard. At the foot of the climb is a large sign directing trucks into the special lane; and observation has proved that they never fail to do so. The section was opened to traffic last August, and no accidents have been reported in the meantime. The prospects are that the state will provide more lanes of this kind at points where conditions are similar and conditions permit.

NEW TURBINE MATERIAL

MODERN steam-driven generating plants produce a given quantity of electric power with one-half as much coal as was required by the best of them twenty years ago. Stated in another way, today's newer central stations develop twice as much power from a pound of coal as could be obtained in 1920. Partly responsible for this marked increase in efficiency are the higher pressures and temperatures at which they now operate. These conditions are the result of the steady improvement in materials for turbine construction.

The rotor in one of the modern turbines is in effect a 20-ton top spinning at a peripheral speed of more than 800 miles an hour within a shell that has to withstand, while heated to almost glowing temperature, pressures such as exist half a mile down in the ocean. Under these conditions the metal "creeps," and the shell stretches but does not rupture. Carbon-steel castings served as turbine materials until temperatures exceeded the 600-to-750° range. Then alloy-steel forgings were substituted, and these have extended operating temperatures to the 800-to-1,000° range.

Now it is announced that still higher temperatures are tolerable, thanks to the development of a new alloy that can be produced at a lower cost than the currently used steels that contain such comparatively expensive metals as molybdenum, tungsten, and vanadium. This alloy is a mixture of iron and the relatively unfamiliar element columbium. According to E.R. Parker of the General Electric Research Laboratory, samples containing 3 per cent of columbium have revealed exceptionally good rupture strength at 1,100°F., a temperature that is not yet commercially obtained but which is being approached in central-station practice.

Columbium-iron is free of carbon and consequently is not a steel. The iron contains the columbium as a finely dispersed, stable compound of iron and columbium. The alloy is reported to be easy to produce and to be readily machinable. In the General Electric laboratories it has been made in two ways. Correct proportions of the powdered metals were mixed, fused, and swaged. It has also been produced in the form of a casting in the usual manner.

Columbium is a steel-gray mineral that is always found in association with tantalum, which it resembles chemically. It was discovered in 1801 by C. Hatchett in New England, and named by him. In 1844, Rose rediscovered it and, not recognizing it as the element already known, called it niobium. Both names are still retained, but columbium is generally applied to it. The metal has the same hardness as wrought iron and melts at 3,542°F. It was at one time used for electric-light lamp filaments, and is now employed to some extent in the jewelry industry. There is also a columbium-stabilized stainless steel. The mineral does not occur in a free state, and those that contain it are comparatively rare. Most of the present small annual production comes from Australia. Investigations indicate that the output could readily be increased to supply the quantities needed for turbine construction.

FOR SAFER DRIVING

DANGEROUS motoring conditions will prevail in northern latitudes during a goodly portion of the next three or four months. Driving practices will have to be amended accordingly, for it is a well-known fact that accidents go up when the mercury goes down.

In an effort to reduce mishaps, the National Safety Council has issued seven safety tips for winter driving. The list was drawn up by a committee of 32 engineers, public officials, transportation experts, and safety authorities. This group didn't reach its conclusions around a conference table. Instead, it went out on the frozen surface of Lake Cadillac, Mich., last winter and studied the behavior of automobiles when driven under actual snow and ice conditions. More than 3,000 tests were conducted and nothing was taken for granted.

Despite the fact that there are fewer cars in use in the wintertime, traffic death rates go up from 35 to 45 per cent in northern states and from 3 to 21 per cent in southern states. Skidding is the greatest single cause of these accidents. Whereas it is involved in only one per cent of the accidents on dry roads, it contributes to 27 per cent of them on wet roads and to 50 per cent on snow- or ice-covered roads. Poor visibility, attributable to increased hours of darkness, snow and sleet storms, and fog, is the second greatest cause of accidents. The tests proved some long-held pet theories to be unsound. For instance, the common practice of partially deflating tires on slippery roads was found to be bad. It was disclosed that very slight additional traction for stopping is gained and that there is a greater tendency towards side skidding when rounding curves.

Following are the seven suggestions of the committee: First, check brake linings for simultaneous gripping, as unequalized brakes start skids; second, use tire chains in heavy snow; third, make sure that windshield wipers and defrosters are working properly and that lighting equipment is adequate for additional hours of darkness and for snow, fog, and sleet. Dim or depress headlights when passing cars. Fourth, travel at reduced speeds on snow or ice, even when using chains, and watch out for children on sleds. Although tire chains provide needed traction for stop-and-go travel on snow or ice, they do not make high speeds safe. Fifth, don't follow the car ahead closely. Don't attempt to pass cars on hills or curves, and approach icy curves slowly, even when the road is sanded or when your tire chains are on; sixth, slow down with the car in gear and "pump" brakes on-off-and-on to keep wheels from locking completely, especially when not safeguarded by chains; and, seventh, exercise more caution generally and open cowl ventilator to force out carbon-monoxide gas, especially in the case of old cars.

Air Motor Drives Pump in an Emergency

NECESSITY is the mother of invention. Most of us have had that fact brought home to us at one time or another. So did Pacific Constructors, Inc., builders of Shasta Dam, when heavy rains damaged a bridge over the Sacramento River and temporarily put it out of service. High water washed out the center span of that steel structure by which men, materials, and supplies reached the west bank of the stream or dam site. To restore communication and to continue operations at that point a catwalk was swung across, and this served from February 28 to March 3, when normal conditions were again restored. Shasta Dam is a part of the great California Central Valley Project of the U.S. Bureau of Reclamation and will be exceeded in height only by the Boulder Dam on the Colorado River and in mass by the Grand Coulee Dam on the Columbia.

With the temporary crossing in place, there still remained the problem of maintaining the supplies of fuel oil, gasoline, and butane. Here is where the ingenuity came in, and it was displayed by George L. Malan, machine-shop foreman of Pacific Constructors, Inc. What was done has been described as follows by the Sacramento Division of the Tide Water Associated Oil Company, which assisted in the emergency operations.

Our butane truck and one gasoline truck were driven to Kennett empty, taken across the condemned bridge, put on flat cars, and brought down to the dam site on the opposite bank of the river, where they were unloaded to serve as storage tanks. Three 2-inch lines, each approximately 250 feet long, were run across the catwalk for heavy oil, gasoline, and butane, respectively, and were connected to the storage facilities on the isolated or west side and to the delivery trucks on the east side. The two first-named fuels were transported in regular tank trucks and transferred without difficulty by means of power-driven pumps. But with our butane truck serving as a storage tank for the time being, we had to haul the gas in a trailer and to force it through the line with a wobble pump. This was hand operated at the start, a procedure that was found to be too slow because the trailer was needed to supply butane elsewhere on the dam site and in the district.

In casting about for a quicker and equally safe means of transferring the inflammable gas, Mr. Malan conceived the idea of connecting the pump to a compressed-air motor, and this he did by means of a disk with a short side rod which he fastened to the hand lever. The disk was made and geared so that it was not possible to overspeed the pump; and the air to drive the motor was taken from one of the regular 3-inch lines on the job by a hose connection. This method proved satisfactory, and enabled us during the period the bridge was out of service not only to supply all the butane required on the west bank of the Sacramento at the Shasta Dam site but also for equipment on the east bank and on another job some 14 miles away on the Pit River.

EMERGENCY EQUIPMENT

George L. Malan, machine shop foreman of Pacific Constructors, Inc., at Shasta Dam, and the 350-gallon butane trailer after the wobble pump, mounted immediately left of the wheel, had been changed by him from hand to air-motor drive. The latter unit, with the air hose attached, is seen in the left center and served to operate the lever of the wobble pump through the medium of the intervening disk and side rod. Short lengths of two of the three lines by which butane, fuel oil, and gasoline were delivered to the west bank of the Sacramento during the bridge washout are visible below the sign at the east end of the temporary catwalk.

Flexible Core Wall for Dam in Earthquake Zone

IN COUNTRIES in which earthquakes must be reckoned with, the problem of the construction engineer is a difficult one. Burma is such a region, and the Pegu-Yomas earth dam, forming a new reservoir for the water-supply system of the City of Rangoon, has special features designed to enable it to withstand such shocks. It has a flexible core wall, 130 feet high and 350 feet long at the crest, built of reinforced-concrete poured in panels 25 feet long, 10 feet high, and ranging in thickness from 8 feet at the base of the structure to 4 feet at the top. Each side of the wall has a batter of 1 in 80. These panels are connected both horizontally and vertically by tongue-and-groove joints.

In the top of each block is a 9-inch V-groove partly filled with asphalt in which is embedded the lower edge of a longitudinal copper strip. In the bottom is a V-groove 3 inches deep in which is a similar strip. These overlap, and the joint is sealed with asphalt. In addition, the panels are separated by bituminous sheeting. The vertical joints consist of rows of precast concrete blocks: two rows down one side of each panel forming a channel approximately 8x11 inches in size, and one row down the other. The latter constitutes the tongue, and from it copper strips project diagonally to the sides of the channel, which is filled with asphalt. Suitable means are provided to prevent this material from escaping; and in case of loss, it can be replenished by the aid of pipes extending through a wave wall, 4½ feet high, at the top and along the upstream side of the structure.

In designing the Pegu-Yomas Dam the engineers were influenced by the behavior of an earth dam with a puddled core wall that was exposed to the destructive forces of a temblor in Japan. Although displaced and left in the shape of the letter S, the wall remained unbroken. Suitable clay not being available in Burma, the flexible concrete core wall was developed. According to the calculations, the joints will remain tight even if the structure is subjected to considerable angular movement and is shifted as much as 16 feet out of line. The dam was designed by Binnie, Deacon & Gourley, consulting engineers of London, England.

Industrial Notes

E. F. Houghton & Company, oil and leather manufacturer, has announced a new series of rust preventives that differs from others in the basic material used. The latter is said to assure a homogeneous, noncrystalline film with a high degree of cohesion, as well as adhesion, to metals. It wets out the surfaces rapidly, providing an unbroken, nontacky coating impervious to atmospheric conditions. The series includes liquid and grease-type nondrying products, hard-film drying preventives, and semidrying and soluble protective coatings. All these are described in a folder, *Houghton on Rust Prevention*, which may be obtained by sending requests to Third & Somerset streets, Philadelphia, Pa. In addition, as an aid to industry, the company has developed a method by which the testing of rust preventives can be accelerated in order to determine the one most suitable for a given service.

One of the claims made for the Alemite tire mounter, a new product of Stewart-Warner Corporation, is that it reduces to a matter of approximately ten seconds the troublesome job of tire mounting. The tool is a portable one and can be operated in any position by compressed air. It is equipped to fit the ordinary air chuck used for tire inflation, and will mount any tire on 15- and 16-inch drop-center rims. When air pressure is applied, a patented shoe

automatically flips the tire bead over the rim, thus preventing pinched tubes, scuffed white-side walls, and strained cords or beads that lead all too frequently to premature tire failures. The tool weighs 15 pounds and is designed primarily for the use of service stations, tire repair shops, and fleet operators.

For loads weighing 700 pounds and less, Ingersoll-Rand Company has introduced an air-operated, link-chain hoist, the Air-Bloc, which is available in three models capable of lifting 300, 500, and 700 pounds, respectively. Each of the new units weighs less than 75 pounds and is powered by a 4-cylinder, radial-type air motor which can-

not be injured by overloading. All moving parts are automatically lubricated in a dustproof oil chamber; and a graduating, reversing valve gives instant and full control of the hoist action so that the operator can ease or spot the load with great accuracy. Flexible, welded link chain is used, and automatic safety stops prevent damage to the hoist if the chain is allowed to overrun in either direction. The Air-Bloc has a maximum lift of 10 feet, and with air at 80 pounds pressure raises the load at the rate of 25, 20, or 12 feet per minute, depending upon the weight. The construction is such that, even should the air supply fail, the load would not drop. An illustrated folder describing this new Ingersoll-Rand product can be obtained upon request from the company at 11 Broadway, New York City, or any of its branches.

By passing metal tubing at from 15 to 100 feet per minute through a newly developed testing machine it is possible, it is claimed, to determine whether it is free from dents or other external and internal imperfections. By means of four motor-driven rollers, the tube is advanced through a centrally located searching unit the sensitivity of which can be adjusted to detect all defects or to pass over minor ones. When a flaw is encountered, a light is flashed and the machine stops immediately, if set to do so, or it continues to function—a pair of lights being provided at the far end to permit the inspection of visible defects. Operations can be halted at any time and travel reversed. Tubes of both magnetic or nonmagnetic metals can be handled, and a set of 8 extra rollers is supplied so that one machine can test tubes ranging in diameter from ½ to 2½ inches. Larger diameters call for a larger searching unit.

The Eimco Corporation of Salt Lake City has established new and enlarged branch-office headquarters in New York City at 120 Broadway, including a service department that will carry Eimco-Finlay loader parts in stock.

Successive layers of paint on the walls, ducts, fans, etc., of spray booths can be disposed of without difficulty, it is claimed, by covering those surfaces with Boothcoat. The material is made by Harris Soap Company, and is now obtainable in an improved form in 5-, 30-, and 55-gallon containers. It is applied by brushing or spraying, and peels off readily in sheets, bringing the waste paint along with it.

Super-Seal plastic packing made by the Crane Packing Company, Chicago, Ill., has been improved upon by providing it with a patented tape-back reinforcement firmly vulcanized to the outer surface of the packing, as shown in the accompanying picture. This reinforcement takes the place of the former frictional, woven cotton jacket and presents a nonfrictional bearing surface to the moving part. Because of the tape back the packing is said to be extremely pliable and can be bent around small-diameter rods and shafts without fracturing or cracking, or it can be formed into small internal-diameter rings without distortion. It is recommended for centrifugal and rotary services and comes in six styles for a wide range of uses and temperatures. Each style is available in coils and standard-length spirals or die-formed rings or sets made to stuffing-box dimensions and in sizes ranging from ¼ inch to 1 inch graduated in sixteenths. The company is prepared to send samples upon written request.

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